THE SECRET GUIDE

TO COMPUTERS

VOLUME 3: POPULAR SYSTEMS

contains candid comments about competing computer companies
IBM, DEC, Radio Shack, Apple, Commodore, and many others
microcomputers, disks, printers, terminals, and other devices
explains fundamental jargon, and tutors you in the tough stuff

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Dear You!

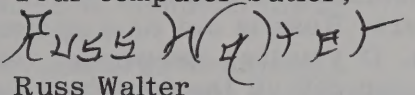
Welcome to volume 3 of *The Secret Guide to Computers*. This volume turns you into an expert about computer equipment. It contrasts the various kinds of equipment, defines the technical buzzwords, compares manufacturers, advises you on what to buy, and reveals tricks for saving money.

Pages 1 through 64 were written in 1980, and contain an in-depth look at the state of the computer industry then. To find out what happened in 1981, read page 65, and then— for an even deeper look at 1981— read the next volume, which is volume 4. (But before you launch into volume 4, finish volume 3, which gives you the necessary background.)

If you don't have volume 4 yet, get it by using the coupon on page 66.

If you have any questions— about 1980, or 1981, or 1982, or about your own personal problems— phone me at 617-266-8128. You can call 24 hours: I'm almost always in, and I sleep only lightly. I'm waiting to hear your questions!

At your service,
Your computer butler,



Russ Walter

P.S. Here's a sneak preview....

COMPLETE COVERAGE

This volume explains computer equipment and compares the manufacturers. It covers all three computer sizes (maxicomputers, minicomputers, and microcomputers), all three kinds of computer equipment (CPU, memory, and I/O devices), and all three kinds of vendors (manufacturers, traditional dealers, and discount dealers). It covers the three most "popular" microcomputer companies (Radio Shack, Apple, and Commodore) and their competitors (which in some ways are better).

NO PREREQUISITES

You can understand this volume even if you've never dealt with computers before. All the jargon and concepts are explained.

PHONE BOOK

The computer industry's phone book begins on page 2. You get the name, address, and phone number of each company, including even the discount dealers. The phone book also acts as an index: to analyze a company quickly, look up the company in the phone book and then turn to the page that the phone book recommends. That page will tell you about the company's main product and its competitors. Also look at the table of contents, which will help you find detailed chapters on such equipment.

JARGON DICTIONARY

The dictionary of computer jargon begins on page 4. Whenever somebody uses a computer term that you don't understand, look it up in the dictionary, which will give you a quick, simple definition. The dictionary also acts as an index: it tells you which page to turn to, for a complete, thorough analysis of the computer term.

PRACTICAL EMPHASIS

This volume tells you the least expensive way to computerize your application pleasantly. To make sure the result is inexpensive, this volume usually recommends microcomputers (instead of minicomputers or maxicomputers). To make sure the result is pleasant, this volume usually recommends disks (instead of tapes) and video screens (instead of teletypewriters or punched cards). If you're using a video screen, you'll also want a printer; so this volume also emphasizes printers.

OBJECTIVE EVALUATIONS

This volume is as unbiased as possible. For every type of computer equipment, this volume offers several competing manufacturers. For every major manufacturer, this volume dishes out both praise and criticism.

Services

We are missionaries. Our mission: to give you all the help you want, and charge you little or nothing for it. Like missionaries in the Catholic Church, we live on peanuts.

FREE CONSULTING

Whenever you have a question about computers and want personal help, call (617) 266-8128, and ask for Russ. You'll get all the consulting you wish. It's free! There's no time limit. Call as often as you wish. Call for help on all your personal hassles and for up-to-the-minute inside news about the computer industry. This no-charge public service has already saved readers many kilohours and kilobucks.

You can call 24 hours. (Remarkable Russ sleeps only lightly; he's like a "doctor on call".) The probability is 85% that you'll get him immediately. If you're unlucky, and nobody answers, Russ is out on a project; please call again a few hours later.

He's in Boston. If you live elsewhere, remember that phone calls can be cheap: for example, you can call all the way from California to Boston for *just 6¢ initially, plus 16¢ per minute*. To get that low rate, call without using an operator, and call anytime Saturday, or on Sunday before 5 PM, or on weekdays before 8 AM or after 11 PM.

EIGHT VOLUMES

The Secret Guide to Computers consists of eight volumes. Each volume contains information you ought to know before you buy a computer. The volumes cost very little, and you can get discounts. To order them, use the coupon on page 66.

INTENSIVE COURSES

Russ offers many courses in many cities. The courses cost little or nothing, and turn you into a computer expert quickly. To find out about them, use the coupon on page 66.

YOUR INPUT

If you make, sell, use, or hear about an interesting computer product, please send us information about it.

If you're a manufacturer and want to send us a sales blurb, please include (if possible) the quantity-one end-user list price, the OEM discount price, the anticipated delay in shipments, the technical specifications, and a list of additional software and hardware the user must buy in order to operate your product. If you're selling hardware, please also send (if possible) manuals about the software: a reference manual *and* a tutorial manual. If you can send us a demonstration unit, great! If you wish, we'll return the manuals and demonstration unit within one week. We'll also give you a free critique of your product, including suggestions on how you can improve the product further. If your product is *highly useful* and *superior to its competitors*, we'll also give you free publicity.

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Friends

Company	Phone	Page
AB Computers, 115 E. Stump Rd., Montgomeryville, PA 18936	215-699-8386	58
Altos Computer Systems, 2378B Walsh Ave., Santa Clara, CA 95050	408-244-5766	11
American Square Computers, Kivett Dr., Jamestown, NC 27282	919-883-1105	64
Anadex, 9825 De Soto Ave., Chatsworth, CA 91311	213-998-8010	19
APF Electronics, 444 Madison Ave., New York, NY 10022	212-758-7550	24
Apple Computer, 10260 Bandley Dr., Cupertino, CA 95014	408-996-1010	11
Arp Instruments, 45 Hartwell Ave., Lexington, MA 02173	617-861-6000	25
Atari/Warner, 1265 Borregas Ave., Sunnyvale, CA 94086 (CA: 800-672-1404)	800-538-8547	11
Axiom, 5932 San Fernando Rd., Glendale, CA 91202	213-998-8010	19
Base Two, P.O. Box 3548, Fullerton, CA 92634	714-533-0111	19
BASF Systems, Crosby Dr., Bedford, MA 01730	617-271-4000	63
Burroughs, Burroughs Pl., Detroit, MI 48232	313-972-7442	10
California Computer Products, 2411 W. La Palma Ave., Anaheim, CA 92801	714-821-2011	22
C and S Electronics Mart, 32 E. Main, Milan, MI 48160	313-439-1508	51
Centronics Data Computer, 1 Wall St., Hudson, NH 03051	603-883-0111	19
Commodore Business Machines, 3330 Scott Blvd., Santa Clara, CA 95050	408-727-1130	11
Compucolor, P.O. Box 569, Norcross, GA 30071	404-449-5996	11
Compumart/NCE, 270 Third St., Cambridge, MA 02142 (MA: 617-491-2700)	800-343-5504	54
Compusoft, P.O. Box 19669, San Diego, CA 92119	714-465-3322	45
Computalker Consultants, Box 1951, Santa Monica, CA 90406 (also: 392-5230)	213-828-6546	25
Computer Printers International, 340 E. Middlefield Rd., Mt. View, CA 94043	415-969-6161	19
Computer Shop, 16919 Hawthorne Blvd., Lawndale, CA 90260	213-317-4010	53
Control Data, P.O. Box O (8100 34th Ave.), Minneapolis, MN 55440	612-853-8100	10
Corvus Systems, 900 S. Winchester Blvd., San Jose, CA 95128	408-246-0461	41
Cromemco, 280 Bernardo Ave., Mountain View, CA 94043	415-964-7400	11
Data General, Route 9, Westboro, MA 01581	617-366-8911	11
Digital Equipment, 146 Main St., Maynard, MA 01754	617-897-5111	10
Exidy (Data Products Div.), 390 Java Dr., Sunnyvale, CA 94086	408-734-9410	11
Factory Direct Sales (Dept. 304), 1317 E. Colorado St., Glendale, CA 91205	213-245-1417	62
Federal Screw Works, 500 Stevenson Highway, Troy, MI 48084	313-585-8737	25
Hazeltine, Greenlawn, NY 11740	516-261-7000	17
Heath/Zenith, Benton Harbor, MI 49022 (catalog orders, 24 hours: 982-3411)	616-982-3285	11
Hewlett-Packard, 1501 Page Mill Rd., Palo Alto, CA 94304	415-856-2067	10
Honeywell, Honeywell Plaza, Minneapolis, MN 55408	612-870-2700	10
Integral Data Systems, 14 Tech Circle, Natick, MA 01760	617-237-7610	19
Intel, 3065 Bowers Ave., Santa Clara, CA 95051	408-987-8080	44
International Business Machines, Old Orchard Rd., Armonk, NY 10504	914-765-1900	10
International Memories, 10381 Bandley Dr., Cupertino, CA 95014	408-446-9779	41
Intertec Data Systems, 2300 Broad River Rd., Columbia, SC 29210	803-798-9100	11
Kurtzweil Computer Products, 33 Cambridge Parkway, Cambridge, MA 02142	617-864-4700	25
Lear Siegler (Data Products Div.), 714 N. Brookhurst, Anaheim, CA 92803	714-774-1010	19
Lobo Drives International, 935 Camino Del Sur, Goleta, CA 93017	805-685-4546	41
Micro Management Systems, 115C 2nd Ave. SW, Cairo, GA 31728	912-377-7120	51
Micro Peripherals, 21201 Oxnard St., Woodland Hills, CA 91367	213-999-2870	19
Micropolis, 7959 Deering Ave., Canoga Park, Northridge, CA 91304	213-703-1121	39
Microsoft, 10800 N.E. Eighth (Suite 819), Bellevue, WA 98004	206-455-8080	45
MOS Technology/Commodore, 950 Rittenhouse Rd., Norristown, PA 19401	215-666-7950	44
Motorola Semiconductor Products, 3501 Ed Bluestein Blvd., Austin, TX 78721	512-928-2600	44
Multi-Business Computer Systems, 28 Marlborough St., Portland, CT 06480	203-342-2747	58
NCR, 1700 S. Patterson Blvd., Dayton, OH 45479	513-449-2000	10
NEC Systems Lab./Nippon Electric, 5 Militia Dr., Lexington, MA 02173	617-862-6415	10
North Star Computers, 1440 Fourth St., Berkeley, CA 94710	415-527-6950	11

Ohio Scientific, 1222 S. Chillicothe Rd., Aurora, OH 44202 (OH: 216-562-3101)	800-321-6850	11
Okidata/Oki Electric Industry, 111 Gaither Dr., Moorestown, NJ 08057	609-235-2600	19
Olensky Brothers (Computer Sales Div.), 3763 Airport Rd., Mobile, AL 36608	205-344-7448	53
Pan American Electronics, 1117 Conway, Mission, TX 78572 (TX: 512-581-2765)	800-531-7466	51
Percom Data, 211 N. Kirby, Garland, TX 75042 (TX: 214-272-3421)	800-527-1592	40
Pertec Computer, 12910 Culver Blvd., Los Angeles, CA 90066	213-822-9222	39
Qume, 2323 Industrial Parkway West, Hayward, CA 94545	415-783-6100	16
Radio Shack/Tandy, 1800 Tandy Ctr., P.O. Box 17180, Ft. Worth, TX 76102	817-390-3021	11
Raygam/Com. W., 6791 Westm. Ave., Westminster, CA 92683(CA:714-891-2587)	800-854-6455	53
Shugart Associates/Xerox, 415 Oakmead Parkway, Sunnyvale, CA 94086	408-733-0100	39
Siemens Corp./Siemens AG, 186 Wood Ave. South, Iselin, NJ 08830	201-494-1000	10
Sperry Rand, 1290 Ave. of the Americas, New York, NY 10019	212-956-3273	10
Teletype/ Western Elec./A.T.&T., 5555 Touhy Ave., Skokie, IL 60076	312-982-2000	13
Texas Instruments, P.O. Box 225474, Dallas, TX 75265	214-238-2011	11
Three M, 3M Center, St. Paul, MN 55101	612-733-1110	35
Ucatan Computer Store, P.O. Box 1000, Destin, FL 32541 (also: 243-8565)	904-837-2022	53
Vector Graphic, 31364 Via Colinas, Westlake Village, CA 91361	213-991-2302	11
VR Data, 777 Henderson Blvd. N-6, Folcroft, PA 19032 (PA: 215-461-5300)	800-345-8102	50
Wangco/Perkin-Elmer, 5404 Jandy Pl., Los Angeles, CA 90066	213-390-8081	63
Your Own Computer, 10678 Campus Way South, Largo, MD 20870	301-350-6680	53
Zilog/Exxon, 10460 Bubb Rd., Cupertino, CA 95014	408-446-4666	44

Abbrev.	Full name
Calcomp	California Computer Products
CBM	Commodore Business Machines
CDC	Control Data Corporation
Comprint	Computer Printers Internat'l
DEC	Digital Equipment Corporation
HP	Hewlett-Packard
IBM	Internat'l Business Machines
IDS	Integral Data Systems
IMI	International Memories Inc.
MPI	Micro Peripherals Inc.
NEC	Nippon Electric Company
OSI	Ohio Scientific Incorporated
TI	Texas Instruments

Product	Description	Page
ADM-3A	display terminal by Lear Siegler	17
Applesoft	BASIC ROM by Apple	52
Brighterwriter	serial RO printer by Integral Data	20
Challenger	microcomputer by Ohio Scientific	11
Decwriter	teletypewriter by DEC	13
Dumb Terminal	display terminal by Lear Siegler	17
Eclipse	minicomputer by Data General	11
Heathkit	microcomputer by Heath	11
Horizon	microcomputer by North Star	40
Intertube	display terminal by Intertec	17
KIM	microcomputer by MOS Technology	44
Microline	serial RO printer by Okidata	20
Minidiskette	5" floppy disk by Shugart	36
Minifloppy	5" floppy disk drive by Shugart	36
MZ	microcomputer by Vector Graphic	60
Nova	microcomputer by Data General	11
Odyssey	music synthesizer by Arp	25
Paper Tiger	serial printer by Integral Data	20
PDP-11	minicomputer by DEC	11
PET	microcomputer by Commodore	11
ROM Pac	ROM cartridge by Exidy	32
RP06	hard disk drive by DEC	41
Selectric	teletypewriter by IBM	15
Silent 745	teletypewriter by TI	14
Sorcerer	microcomputer by Exidy	11
Spinwriter	teletypewriter by NEC	15
Sprint 5	teletypewriter by Qume	16
Superbrain	microcomputer by Intertec	11
TRS-80	microcomputer by Radio Shack	11
Univac	maxicomputer by Sperry Rand	11
VAX	minicomputer by DEC	11
Votrax	voice synthesizer by Fed. Screw	25
Z-80	microprocessor by Zilog	44

Buzzwords

acoustic coupler: a box that beeps into a telephone page 27
American Standard Code for Information Interchange: the code most TTY's use 15
archives: piles of data that are relatively unimportant and used very rarely 35
ASCII: American Standard Code for Information Interchange 15
ASCII/EBCDIC converter: a box that converts between ASCII and EBCDIC 15
audio cassette drive: an ordinary cassette tape recorder 34
authorized dealer: a dealer that can give you the manufacturer's warranty 50
auxiliary memory: slow, cheap memory 29

backup tape: fail-safe backup tape 35
baud: bits per second 17
bidirectional printer: a serial printer that prints even while returning the head 19
bipolar RAM: the fastest, most expensive kind of RAM 31
bit: an electronic signal; to transmit a character, you must transmit several bits 17
buffer storage unit: cache 31
byte: a character 28

cache: the fastest part of the main memory 31
card punch: it's like a keypunch machine, but run by a computer, not a human 22
card reader: a device that reads punched cards 22
cartridge tape drive: it's like a digital cassette drive, but uses a different shape 34
cathode-ray tube: a television screen 17
central processing unit: the computer's brain 9
central processor: central processing unit 9
character: a letter, digit, punctuation mark, blank, or other symbol 13
chip: semiconductor chip 30
controller: electronic circuitry that controls a tape drive or disk drive 34
core: a tiny metal doughnut, used in the main memory of an old computer 32
correspondence code: the code IBM's teletypewriters use 15
cpi: characters per inch 13
cpl: characters per line 14
cps: characters per second 13
CPU: central processing unit 9
CPU cabinet: the cabinet that contains the CPU 29
CRT: cathode-ray tube 17
CRT terminal: display terminal 17

daisy wheel: a plastic or metal daisy, whose petals contain engraved characters 15
digital cassette tape drive: a cassette tape recorder made specially for computers 34
digitized sound: the code that represents a sound 24
digitizing a sound: turning a sound into a computer code 24
DIP: dual in-line package 30
directory: the file that tells where to find all the other files 38
disk: a form of auxiliary memory that looks like a phonograph record 33
disk cartridge: a round plastic covering for a hard disk 36
disk drive: a machine that you put disks into 33
diskette: floppy disk 36
disk operating system: a series of programs that help you use the disk drive 46
disk pack: a stack of hard disks 36
display terminal: it's like a teletypewriter, but uses a screen instead of paper 17
DOS: disk operating system 46
dot-matrix character: a character composed of many tiny dots, close together 14
double-density: twice as many bytes per track 37
drive: a tape drive or a disk drive 33
drum plotter: a plotter that draws on a roll of paper 22
dual in-line package: it looks like a caterpillar; its belly contains a chip 30

EBCDIC: Extended Binary-Coded-Decimal Interchange Code 15
elite: 12 characters per inch 13
expansion interface: a box that lets you expand your computer 46
Extended Binary-Coded-Decimal Interchange Code: the code IBM computers use 15

fail-safe backup tape: tape that holds a copy of what's on a disk 35
feeding the paper: jerking the paper up 15
ferric oxide: rust 33
file: a group of t-sectors that has a name 38
fixed-head disk drive: a disk drive whose heads never move 37
flat-bed plotter: a plotter that draws on a flat sheet of paper 22
floppy disk: a thin, bendable disk 36
flying-head disk drive: a drive where a breeze separates the head from the disk 37
format a disk: organize the surface of a disk 38
formatted capacity of a disk: how many of the disk's bytes are for data 38
friction-feed teletypewriter: a teletypewriter that uses friction to feed the paper 15
fully-formed character: a character composed of lines and curves, not dots 14

G: gigabyte 28
gigabyte: a billion bytes 28
golf ball: a plastic ball on which characters are engraved 15
graphics character: a character that's not used for English or math 57
graphics display terminal: a terminal that lets you draw fancy pictures on screen 18

hard copy: information printed on paper 13
hard-copy terminal: teletypewriter 13
hard disk: a disk that's not bendable 36
hardware: computer equipment 9
hit rate: the probability that some desired information is already in the cache 31
hood: a device containing mechanical fingers that press a typewriter's keys 21

IBM card: a punched card designed by IBM 22
IC: integrated circuit 30
impact printer: a printer containing a ribbon that hits the paper 15
input device: a device that takes information in from humans 9
input hopper: the card reader's bin where you put the cards to be read 22
integrated circuit: semiconductor chip 30
interface: a connection between two devices 15
interface card: a PC board that acts as an interface 53
I/O: input and output 9
I/O device: a device that lets the computer communicate with humans 9

jacket: it protects a floppy disk from scratches and dust 36
joystick: a stick you use with a graphics display terminal 18

K: kilobyte 28
keyboard send-receive printer: teletypewriter 13
keypunch machine: it looks like a typewriter, but uses IBM cards, not paper 22
kilobyte: a thousand bytes 28
KSR printer: keyboard send-receive printer 13

light pen: a pen you use with a graphics display terminal 18
line printer: a printer that prints many characters simultaneously 19
loading from the memory: reading the memory 28
lower-case letter: a letter that isn't capitalized 14
lpm: lines per minute 20

M: megabyte 28
machine language: a primitive language that consists of just zeros and ones 44
magnetic ink: ink that contains magnetic particles 23
magnetic-ink character-recognition reader: a scanner that sees only magnetic ink 23
main cabinet: CPU cabinet 29
mainframe cabinet: main cabinet 29
mainframe computer: maxicomputer 9
main memory: quick, expensive memory 29
matrix character: dot-matrix character 14
maxicomputer: a big computer 9
medium: the tape or disk (as opposed to the drive) 33
megabyte: a million bytes 28
metal-oxide semiconductor field-effect transistor RAM: the most popular RAM 31
microcomputer: a teensy-weensy computer 9
microprocessor: a CPU that consists of a single chip 44
microprocessor unit: microprocessor 44
microsecond: a millionth of a second 28
MICR reader: magnetic-ink character-recognition reader 23
millisecond: a thousandth of a second 28
minicomputer: a small computer 9
modem: modulator/demodulator 27
modulator/demodulator: a device that converts between the two kinds of signals 27
MOSFET RAM: metal-oxide semiconductor field-effect transistor RAM 31
MOS RAM: MOSFET RAM 31
mouse: a mechanical mouse you use with a graphics display terminal 18
moving-head disk drive: a disk drive whose heads move 37
MPU: microprocessor unit 44
ms: millisecond 28
msec: millisecond 28

nanosecond: a billionth of a second 28
non-impact printer: a printer that involves no hitting 15
non-removable disk: a disk you cannot remove from the disk drive 36
ns: nanosecond 28
nsec: nanosecond 28
numeric keypad: a keypad on right side of the keyboard; it contains the digits 17

OCR reader: optical character-recognition reader 23
OEM: original equipment manufacturer 12
OMR reader: optical mark-recognition reader 23
one-sided disk: a disk whose flip side is blank 36
optical character-recognition reader: an optical scanner that reads letters & num. 23
optical mark-recognition reader: an optical scanner that sees only dark squares 23
optical scanner: a scanner that works by shining a light at the paper 23
original equipment manufacturer: a company that makes computers 12
output device: a device that spits information out 9
output hopper: the bin where the card reader puts the cards it has read 22

paddle: a lever you use with a graphics display terminal 18
PC board: printed-circuit board 30
peeking at the memory: reading the memory 28
physical record: the part of the t-sector that contains your data (instead of ID) 38
pica: 10 characters per inch 13
plotter: a computerized device that draws on paper, by using a pen 22
printed-circuit board: a plastic board on which an electrical circuit is printed 30
printer: any device that prints on paper 19
printer terminal: teletypewriter 13
print head: the part of a serial printer that moves across the paper and prints 19
proportional spacing: giving each character a different width 13
punched card: a card (made of cardboard) that has holes punched in it 22

radio-frequency modulator: a box that turns messages into radio waves, for TV 18
RAM chips: random-access read-write memory chips 30
random access: skipping around, in the data 34
random-access read-write memory chips: chips that contain temporary information 30
reading the memory: finding out what information is in the memory 28
read-only memory chips: chips that contain permanent information 31
read/write head: the part of the drive that reads and writes the tape or disk 33
receive-only printer: a printer that lacks a keyboard 19
reel-to-reel tape drive: the most expensive and fastest kind of tape drive 34
removable disk: a disk you can remove from the disk drive 36
request for proposal: a memo about what computer capabilities you need 12
retrieving from the memory: reading the memory 28
RF modulator: radio-frequency modulator 18
RFP: request for proposal 12
ROM cartridge: a cartridge that contains some ROM 32
ROM chips: read-only memory chips 31
RO printer: receive-only printer 19
rpm: revolutions per minute 36
rps: revolutions per second 39
RS-232C interface: the interface used by most teletypewriters 15

saving in memory: writing into the memory 28
scanner: a computerized device that looks at paper and reads it 23
sec: second 28
secondary memory: auxiliary memory 29
semiconductor chip: a tiny flat piece of metal that contains an electric circuit 30
sequential order: going through the data in order 34
serial printer: a printer that prints just one character at a time 19
status line: a line on the terminal's screen, that shows the terminal's state 17
storage: the memory 9
store: the memory 9
storing in memory: writing into the memory 28

tablet: a drawing-board you use with a graphics display terminal 18
tape drive: a machine that you put tape into 33
teleprinter: teletypewriter 13
teletypewriter: an electric typewriter you can attach to the computer 13
thermal printer: a printer that burns special paper 15
thimble: it looks like a daisy wheel, but its petals are bent 15
track-sector: an arc of a circular track on a disk 38
tractor-feed teletypewriter: a teletypewriter that uses a tractor to feed the paper 15
transfer rate: the rate that info is read from disk, after head's reached the track 38
t-sector: track-sector 38
TTY: teletypewriter 13
two-sided disk: a disk whose flip side isn't blank 36

unauthorized dealer: a dealer that can't give you a manufacturer's warranty 50
unformatted capacity of a disk: the total number of bytes on a disk 38
unidirectional printer: a serial printer that doesn't print while returning head 19
uP: microprocessor (if you can't type the symbol μ) 44
UPC: Universal Product Code 23
Universal Product Code: the bar code on packages in supermarkets 23
upper-case letter: a capital letter 14
upper-case-only teletypewriter: a teletypewriter that can't print lower-case 14
usec: microsecond (if you can't type the symbol u) 28
user RAM: RAM that's used for your own programs and data 45

video display: a television screen 17
video display terminal: display terminal 17
voice synthesizer: a device that can pronounce vowels and consonants 25

Winchester drive: a flying-head disk drive 37
word: a chunk of several characters (chunk's length depends on manufacturer) 28
writing into the memory: putting new information into the memory 28

(Use this page for your own notes)

Fundamentals

KINDS OF HARDWARE

Computer equipment is called *hardware*. You want the computer to think, remember, and communicate with humans. To think, the computer needs a brain; to remember, the computer needs a memory; and to communicate with humans, the computer needs a way to take information in, and a way to spit information out.

The computer's brain is called the *central processing unit*. The abbreviation for *central processing unit* is: *CPU*. Some people call it the *central processor* instead.

The computer's memory is usually called "the memory". People who work for IBM sometimes call it *storage*, since it stores information. People who work in England sometimes call it the *store*.

The part of the computer that takes information in from humans is called the *input device*; to spit information out, the computer uses an *output device*. The phrase "input and output" is abbreviated: I/O. So devices that let the computer communicate with humans are called I/O devices.

So altogether, you need three kinds of computer hardware: a CPU (which is the brain); memory; and an I/O device (which communicates with humans). The largest computers have *many* CPU's, *many* memories, and *many* I/O devices, so that the computer can do many things simultaneously.

SIZES

Computers come in all sizes. Big computers are called *maxicomputers* (or *mainframes*); small computers are called *minicomputers*; and teensy-weensy computers are called *microcomputers*. Usually, a maxicomputer fills a room; a minicomputer fits in a corner; and a microcomputer freaks out on a desktop. Usually, the total cost of a maxicomputer's hardware is between $4,000,000 and $150,000; for a minicomputer, it's between $150,000 and $10,000; for a microcomputer, it's between $10,000 and $300. That's the total cost of just the *hardware*; you must add extra money for the other four ingredients: programs, data, literature, and people. The typical novice makes the mistake of spending the entire computer budget on hardware, and not having enough money left to pay for the programs, data, literature, and people. In a well-balanced budget, hardware should account for *less than half* of the total cost. In fact, spending only 10% of your budget on hardware is often quite reasonable.

My general advice on spending money is: spend as little as possible. Don't buy more hardware than you need. If you buy too much hardware, you won't have enough money left to cover your other expenses.

Some people buy more hardware than they need, under the excuse that "even though we don't need it now, we'll need it later, when our business expands". That's a bad excuse. If you don't need the hardware now, buy it *later*.

PRICE TRENDS

The longer you wait to buy hardware, the lower the price will be; every year, computers get cheaper. A general rule of thumb is: if you wait two years, it will cost half as much. More precisely: suppose you do comparative shopping now, and buy the cheapest hardware that adequately handles your job; if you do the same comparative shopping two years later, you'll find that the cheapest adequate model then costs half as much as the cheapest model available today.

That price reduction is not some kind of "wild idea" of mine. Practically every year, since computers began in the 1940's, the total hardware price has been dropping by 30% a year. If you take a dollar, and deduct 30% of it, you get 70¢; if you then deduct 30% of the 70¢, you get 49¢. So after two years, you're spending 49¢ instead of a dollar. And there's no sign of that trend stopping.

I do *not* mean that if model X costs $1 today, it will cost 49¢ two years from now. What I *do* mean is that two years from now, there will be a new model Y (perhaps sold by a different company), which is almost as good as model X, and which costs only 49¢. Or, more likely, model Y won't quite exist, but there will be a model A that costs about 65¢ and which is *much* better than model X; and there will be a model B that costs about 35¢ and which is only *slightly* worse than model X. As for model X itself, it will probably be selling for an excessive price (about 60¢), and is definitely a silly purchase; you'd do better to buy a model A or model B. But a few idiots will still buy model X, because, during the two intervening years, lots of people bought model X, so that model X has now become famous and obtained a "good reputation", and idiots will pay for the name.

That's what usually happens to a computer company. It begins by selling a model X that's a good deal. When the industry gets excited about model X and starts praising it, people decide that they'd like to buy model X, and don't even bother to look at the competition. As a result, competitors drop their prices quickly (30% a year), whereas the manufacturer of model X drops the price of model X more slowly (a little over 20% a year). After a few years of this trend, the competitors become much better deals than model X.

In this book, I'll explain what computer prices are like today. But remember: two years from now, the world will be entirely different. (And you'll have to buy another edition of this book.)

Some parts of the computer are purely electronic: they are just a bunch of wires and circuits. Other parts of the computer are mechanical: they consists of motors and devices that move back and forth. The price of electronics drops more rapidly than the price of mechanical parts. That means: if model E contains lots of electronics, and model M contains lots of mechanical parts, the price of model E will decrease more rapidly than the price of model M; and so more and more customers will switch over to model E.

LARGE COMPUTER COMPANIES

Which computer companies are the largest? If by "largest", you mean "took in the most money", these companies are the largest:

	Billions of dollars in 1978
1. Internat. Business Machines, Armonk NY	17.1
2. Burroughs, Detroit MI	2.1
3. Sperry Rand, New York NY	2.0
4. Hitachi, Japan	1.9
5. NCR, Dayton OH	1.9
6. Control Data, Minneapolis MN	1.9
7. Toshiba, Japan	1.7
8. Digital Equipment, Maynard MA	1.6
9. Fujitsu, Japan	1.3
10. Honeywell, Minneapolis MN	1.3
11. Cii-HB, France	1.1
12. ICL, Great Britain	1.0
13. Olivetti, Italy	.8
14. Siemens, West Germany	.7
15. Nippon Electric, Japan	.7
16. Hewlett-Packard, Palo Alto CA	.7

That table shows how many billions of dollars each company received, from selling computer equipment and computer services in the calendar year 1978. (Data for 1979 and 1980 isn't in yet.) Several of those companies took in lots of additional money, by selling *non*-computer goods & services (such as typewriters, televisions, and maybe even dishwashers); the table does *not* include that additional money. The table shows the *revenue* (the amount of money taken in); the net profit is much less, since expenses are great. When comparing U.S. revenues against foreign revenues, remember that a lot depends on the foreign exchange rates (how much a dollar is worth, in terms of francs or marks or lira or yen).

According to that table (which is adapted from research by Datamation Magazine and Quantum Science Corporation), the biggest computer company is International Business Machines (IBM). The second biggest is Burroughs. IBM is *much* bigger than Burroughs; in fact, IBM is *8 times* as big as Burroughs. After IBM and Burroughs comes everybody else.

The table shows 16 companies. Look at the countries they come from. Half of the companies (8) are American; a quarter of the companies (4) are Japanese; and the remaining quarter are European (from France, Great Britain, Italy, and West Germany).

POPULAR COMPUTERS

The most popular maxicomputers are made by International Business Machines (IBM), in Armonk, New York. IBM's old maxicomputer was called the IBM 360; then IBM invented an improved version, called the IBM 370; and now IBM has invented further improvements, called the IBM 3031, 3032, 3033, 4331, and 4341. Other improvements are on the drawing board, and are expected to be released soon. The other major manufacturers of maxicomputers are Burroughs, Control Data Corporation (CDC), and Sperry Rand (which makes the Univac computer).

The most popular minicomputers are made by Digital Equipment Corporation (DEC), in Maynard, Massachusetts. DEC's first computer was called the PDP-1. ("PDP" stands for "programmable data processor".) Then DEC invented the PDP-2, PDP-3, etc. At the moment, DEC's most popular computer is the PDP-11, a minicomputer. DEC also makes a souped-up version, called the VAX 11. DEC's other popular computers are the PDP-8 (a small old-fashioned minicomputer), the PDP-10 (an old-fasioned maxicomputer), and the PDP-20 (a newer maxicomputer). Programming a PDP-20 is much pleasanter and easier than programming an IBM maxicomputer; but IBM's salesmen convince novices to buy IBM computers anyway.

The other major manufacturers of minicomputers are Hewlett-Packard (which makes the HP 3000), Data General (which makes the Nova and Eclipse), NCR, and of course IBM. (IBM's old minicomputers were the System/3 and System/7; IBM's newer minicomputers are the System/32, System/34, System/38, Series/1, and IBM 8100.)

The most popular microcomputer is made by Radio Shack, a division of Tandy, in Fort Worth, Texas. It's called the TRS-80. ("TRS" stands for "Tandy's Radio Shack".) It comes in three versions. The most popular version (and rightly so!) is the "Model 1 with Level-2 BASIC". The cheapest version (which is junk) is the "Model 1 with Level-1 BASIC". The fanciest version (which is good but overpriced) is the "Model 2". The second most popular microcomputer manufacturer is the Apple Computer Company (which makes the Apple Computer); third in popularity is Commodore (which makes the PET and CBM computers). The other major microcomputer manufacturers are Atari (which makes the Atari 400 and Atari 800), Texas Instruments (which makes the TI-99/4), Compucolor (which makes the Compucolor 2), Exidy (which makes the Sorcerer), Ohio Scientific Incorporated (which makes the OSI Challenger), Intertec (which makes the Superbrain), Zenith (and its subsidiary, Heath, which makes the Heathkit), North Star, Vector Graphic, Altos, and Cromemco; but the list will change quickly, since many other companies are trying to get into the act.

What's "popular" is not necessarily what's "best"; what "sells the most" is not necessarily what's "best to buy". So don't look at just the computers that are most popular; look at the competition also.

KINDS OF PRICES

A company that makes computers is called an *original equipment manufacturer (OEM)*. To make the computers, the OEM buys computer parts from other companies.

When you read an ad, you'll sometimes see a low price followed by an asterisk. At the bottom of the ad, in tiny print, you'll see the word "OEM". That means: the low price is the price that the company charges OEM's; for *you*, the price is probably higher. To get that low price, you must usually be willing to buy in quantities of 100; and the computers you'll be buying might be stripped-down models, with the understanding that you'll be adding your own improvements, and printing your own name on the equipment.

If you want to buy just one computer, and you're not an OEM, and you want the computer to be a "complete package" (instead of stripped down), you must pay the "quantity-one end-user packaged price", which is higher than the "quantity-100 OEM mechanism price".

To get a minicomputer or maxicomputer, you can buy, rent, or lease. "Rent" means you pay a certain amount each month, for at least 1 year. "Lease" means you pay a certain amount each month, for at least 2 years. The monthly payment on a lease is less than the monthly payment on rental. When you rent or lease, the computer does *not* belong to you; it belongs to the computer company. When you rent or lease, the computer company automatically takes care of repairs; when you buy, the computer company does *not* automatically take care of repairs, unless you pay for a "service contract", which costs extra, and which you'll probably want. To decide whether to buy, rent, or lease, ask your accountant, who'll tell you about "tax-deductible business expenses", "investment tax credits", and "amortization".

To get a microcomputer, you must buy. If you don't have the cash immediately, you can sometimes buy on the "installment plan", though you'd do better by getting a loan from your bank. Most microcomputers come with a 90-day warranty: if the computer needs repairs during those 90 days, return it, and the company will promptly fix it and give it back to you. After the 90 days are over, you can buy a service contract; but since microcomputers are so cheap and so rarely break down, and since fixing them is so easy, don't waste your money on a service contract: wait until the computer breaks down, and then return it to the company you bought it from and pay the one-time repair charge.

Some "discount houses" buy computers (and parts of computers) in large quantities (and get large discounts), and then resell them at 10%, 15%, or 20% below the list price. If you buy there instead of directly from the manufacturer, you'll save money. You'll also probably get faster delivery: the dealers usually have everything "in stock", whereas the manufacturers are often so swamped with orders that they can't send you anything directly for several months.

Remember that whoever is selling you the computer is trying very hard to "make a sale". If you can prove to him that another company is selling a computer of equal quality at a slightly lower price, and that you're thinking of buying from that other company, he'll probably lower his price, just for you. Then go to the other company, tell the same story, and *that* company will lower *its* price, to match. By going back and forth between the companies several times, you can sometimes knock a huge chunk off the price. For example, one of my students managed to knock off 40%; so as a result of a few phone calls, she saved many thousands of dollars. Life gets fun when you pit the manufacturer against a discount house that sells exactly the same equipment. This whittle-'em-down approach works mainly with minicomputers and maxicomputers; microcomputer dealers work on slimmer profit margins, and therefore aren't able to lower their prices as much.

When a huge organization (such as a university or a government) wants to buy a computer, the organization sends out a *request for proposal (RFP)*, which is a memo explaining what computer capabilities the organization needs. The organization sends the memo to each of the major computer companies, and then waits to see which companies come in with the lowest bids. The lowest bidders are compared on the basis of price *and quality*. If a second round of bidding is allowed, it yields prices that are even lower.

I/O devices

TELETYPEWRITERS

A *teletypewriter* is an electric typewriter that you can attach to the computer. To send a message to the computer, you type the message on the teletypewriter. When the computer wants to reply, it sends the reply to the teletypewriter, and makes the teletypewriter automatically print the reply. Instead of calling it a "teletypewriter", some programmers call it a *teleprinter* or *keyboard send-receive printer (KSR printer)* or *printer terminal* or *hard-copy terminal* (because information printed on paper is called *hard copy*).

Teletypes

The first famous teletypewriters were manufactured by the Teletype Corporation, when called them "Teletypes". The most popular Teletypes were the "model 33" and the "model 35". The model 35 was similar to the model 33, but was built more sturdily.

"Teletype" is a registered trademark of the Teletype Corporation. If you're telling a friend about a teletypewriter that was not manufactured by the Teletype Corporation, and you mistakenly call it a "Teletype", the Teletype Corporation will sue you. So if you're too lazy to say the word "teletypewriter", and want to say just "teletype" instead, do it privately.

Abbreviation

The correct abbreviation for "teletypewriter" is *TTY*. How do you pronounce "TTY"? Most programmers say "tee tee why"; sexy programmers say "titty".

Decwriters

Today, the most popular teletypewriters are made by Digital Equipment Corporation (DEC). DEC's first teletypewriter was called the Decwriter 1; then came the Decwriter 2, then the Decwriter 3, and finally the Decwriter 4.

The Decwriter 1 is obsolete. The Decwriter 2 has been the most popular: DEC has sold 200,000 of them. The Decwriter 3 is much faster than the Decwriter 2, but is much more expensive, and so it's less popular. The Decwriter 4 is a new model that most people don't know about yet; it resembles the Decwriter 2, but is a better deal: it's slightly superior and slightly cheaper, so it obsoletes the Decwriter 2.

Features

Though Decwriters are the most popular teletypewriters, they aren't necessarily the best. Look at the competition. To decide which teletypewriter to buy, look at these features....

Price. Look at the list price, and also ask about discounts. Most teletypewriters cost between $1400 and $3100.

Speed. A *character* is a letter, digit, punctuation mark, special symbol, or blank space. Speed is usually measured in *characters per second (cps)*. Teletype models 33 and 35 print 10 characters per second; IBM Selectric teletypewriters print 15 cps; the Decwriter 2 and Decwriter 4 print 30 cps; other teletypewriters go even faster.

Maximum paper width. Some teletypewriters handle paper that's $8\frac{1}{2}$ inches wide. Other teletypewriters can handle super-wide paper (15 inches wide).

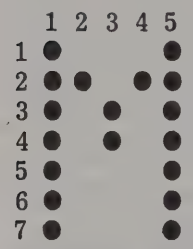
Character width. Most teletypewriters make each character about a tenth of an inch wide; so you get 10 *characters per inch (cpi)*. Other teletypewriters make the characters smaller, so you get 12 characters per inch. 10 characters per inch is called *pica* (pronounced "pie kuh"); 12 characters per inch is called *elite*. Some teletypewriters make each character a different width; so an "M" is very wide and an "i" is narrow; that's called *proportional spacing*.

Characters per line. How many characters can you fit on a line? The answer depends on how wide the characters are, how wide the paper is, and how wide the margins are. Popular answers are: 72 *characters per line (cpl)*, 80 cpl, 132 cpl, and 158 cpl.

Lines per inch. On most teletypewriters, each character is about a sixth of an inch high; so each line is a sixth of an inch high; so you get 6 lines per inch. On sime teletypewriters, you can get 8 or even 12 lines per inch, because the characters are shorter. As a result, you consume less paper, and save money (and trees).

Can it print lower-case? All teletypewriters can print capital letters (such as "A"). Some teletypewriters can also print small letters (such as "a"); other teletypewriters cannot. Capital letters are called *upper-case*; small letters are *lower-case*. If a teletypewriter prints only upper-case, it's called *upper-case only*. The Teletype models 33 and 35 are upper-case only. The committee that invented the Teletype decided that having both upper-case and lower-case would be too expensive. The committee debated which would be better: "upper-case only", or "lower-case only"? Lower-case letters are easier for the human eye to read, so the committee was tempted to make the Teletype be lower-case only; but then someone said, "What about God?" Making "God" be lower-case would be sacrilegious; so the committee finally voted in favor of upper-case only. Even today— because of God— nobody makes lower-case only.

Can it print fully formed characters? On some teletypewriters, the characters are pretty; each character is composed of curves and straight lines; such characters are called *fully formed*. On other teletypewriters, each character is composed of many tiny dots, close together; such characters are called *dot-matrix*, and don't look as pretty as fully-formed characters. The worst kind of dot matrix is "5-by-7"; it makes the letter M look like this:



A better dot matrix uses 7-by-7; the best uses 7-by-9, but still isn't as good as having a fully-formed character.

Can it accept untreated paper? Some teletypewriters require paper that contains aluminum or special chemicals; such paper is expensive.

Can it be easily transported? The "Silent 745" teletypewriter, manufactured by Texas Instruments (TI), weighs less than 17 pounds. Because it's so light, and comes in an attaché case, you can carry it easily. Most other teletypewriters weigh about 50 pounds, and are big and clumsy.

Can it handle friction feed? Can it handle tractor feed? When the teletypewriter finishes typing a line, the teletypewriter must jerk the paper up, so it can print the next line. "Jerking the paper up" is called *feeding the paper*. To feed the paper, a normal typewriter "grabs" the paper, by friction. So teletypewriters act the same way. That's called *friction feed*.

Other teletypewriters feed the paper by sticking metal pins through the paper, and moving the pins. To use such a teletypewriter, you must buy special paper that has holes in the margins, to stick the pins through. On the fanciest teletypewriters, the pins are mounted on a movable *tractor*; you can slide the tractor horizontally, to fit paper of any width; that fancy set-up is called *tractor feed*.

Which is better: friction feed, or tractor feed? Friction feed is inaccurate: sometimes the friction isn't quite enough, and so the paper slips a fraction of an inch. (If the paper slips often, and you're trying to make the computer print paychecks, eventually the slippages will make two names appear on one paycheck!) So friction feed is less accurate than tractor feed. On the other hand, tractor feed is expensive to use, since it requires that you buy special paper that has holes in the margins. Your teletypewriter might handle just friction feed— or just tractor feed— or *both*.

Which printing mechanism does it use? The Teletype model 33 uses a metal cylinder; the characters are engraved on the cylinder; the quality is poor. The IBM Selectric uses a plastic *golf ball*; the letters are engraved all over the golf ball (except that very top and the very bottom of the golf ball are blank); the quality is excellent, if the Selectric isn't broken; however, Selectrics need repairs and adjustments frequently. Many teletypewriters use a *daisy wheel*; the characters are engraved on the petals of the daisy; the daisy is plastic (if cheap) or metal (if expensive); the quality is good (though not as good as a well-adjusted Selectric). The Spinwriter, by Nippon Electric Company (NEC), uses a *thimble*; the thimble looks like a daisy wheel, but the "petals" are bent; the quality is higher than an ordinary daisy wheel, but so is the price. Decwriters use a *matrix* of wires that pokes at the paper; as a result, you see a dot matrix instead of fully formed characters; so the appearance is poor; but the cost is low, and the mechanism is extremely reliable: it hardly ever needs repairs. All those mechanisms (cylinders, golf balls, daisy wheels, thimbles, and matrices) hit a ribbon that hits a paper; so those printers are called *impact printers*. They are all noisy. The quietest print mechanisms are called *non-impact*, because they involve no hitting; instead, most of them "burn" or "electrocute" the paper; such printers require specially treated paper. (If the printer "burns" special paper, it's called a *thermal printer*.)

Which code does it use? Most computers and teletypewriters use the *American Standard Code for Information Interchange (ASCII, which is pronounced "ass key")*. But IBM's computers use a different code instead; it's called the *Extended Binary-Coded-Decimal Interchange Code (EBCDIC, which is pronounced "ebb suh dick")*. IBM's teletypewriters use a dialect of EBCDIC; the dialect is called *correspondence code*. If you want to attach an ASCII teletypewriter to an EBCDIC computer (or vice versa), you must get an *ASCII/EBCDIC converter*, which is a box that converts one code to the other.

Which interface does it use? An *interface* is a connection between two devices. You must make sure that your teletypewriter uses the same interface as your computer. Most teletypewriters use the *RS-232C interface*; but old Teletype models 33 and 35 use a *20 milliamp current loop (20 mA loop)* instead.

Chart

This chart compares 9 famous teletypewriters. Two of them (the Teletype KSR 33 and the Decwriter 2) are becoming obsolete; the others are reasonable to buy.

Manufacturer	Teletype	Teletype	DEC	DEC	IBM	TI	TI	Qume	NEC
Model	KSR 33	KSR 43	Decwriter 2	Decwriter 4	Selectric	Silent 745	820	Sprint 5	Spinwriter
Price (rounded)	$500	$1000	$1500	$1500	$1500	$1500	$2000	$3000	$3000
Speed	10 cps	30 cps	30 cps	30 cps	15 cps	30 cps	150 cps	45 cps	55 cps
Maximum paper width	8½ inches	12 inches	15 inches	15 inches	8½ in.	8½ inches	15 in.	16 inches	8½ inches
Character width	pica	13½ cpi	pica	p.&e.&16½	pica	pica	pica	pica&elite	pica&elite
Characters per line	72	132	132	132	80	80	132	158	163
Lines per inch	6	6	6	2 to 12	6	6	6	6	6&8
Can it print lower-case?	no	yes	yes	yes	yes	yes	yes	yes	yes
Can it print fully-formed char.?	yes	no	no	no	yes	no	no	yes	yes
Can it accept untreated paper?	yes	yes	yes	yes	yes	no	yes	yes	yes
Can it be easily transported?	no	no	no	no	no	yes	no	no	no
Can it handle tractor-feed?	no	no	yes	costs extra	no	no	yes	yes	yes
Printing mechanism	cylinder	7×9 matrix	7×7 matrix	7×9 matrix	golf ball	thermal	7×9 mat.	daisy wh.	thimble
Character's quality	poor	very poor	poor	poor	excell.	poor	poor	good	very good
Equipment's reliability	poor	very good	very good	very good	poor	very g'd	very g'd	good	very good
Usual code	ASCII	ASCII	ASCII	ASCII	corresp.	ASCII	ASCII	ASCII	ASCII
Usual interface	20 mA	RS-232C	RS-232C	RS-232C	RS-232C	RS-232C	RS-232C	RS-232C	RS-232

DISPLAY TERMINALS

A *display terminal* resembles a teletypewriter, but uses no paper. Instead of using paper, the display terminal uses a television screen; whatever is typed appears on the screen.

The screen is called the *video display* or *cathode-ray tube (CRT)*. Instead of saying "display terminal", some programmers say *video display terminal* or *CRT terminal*.

Low-cost display terminals

If you're planning to buy a display terminal, I recommend the Intertube 2, manufactured by Intertec. It costs little, it has excellent quality, and it includes many features.

Its main competitors are the Hazeltine 1400 and Lear Siegler's ADM-3A Dumb Terminal. Let's compare them.

For the Hazeltine 1400, the list price is $850; for the ADM-3A, it's $895; for the Intertube 2, it's $995. But do *not* pay the list price! Many mail-order houses and computer stores offer big discounts, on all three terminals. For example, several dealers sell the Hazeltine 1400 for $649, and sell the Intertube 2 for $745.

For all three terminals, the screen is 12 inches (measured diagonally). The screen shows 24 lines of text; each line contains 80 characters. (The Intertube 2 also shows a special "25th line", called the *status line*, which tells you what state the terminal is in.)

Each character is a dot matrix. On the Hazeltine 1400 and the ADM-3A, the matrix is 5-by-7; on the Intertube 2, the matrix is 8-by-8, which is better.

The Intertube 2 can print both upper-case and lower-case. The Hazeltine 1400 and ADM-3A normally print just upper-case; if you want lower-case also, you must pay extra; it's an "option".

The Intertube 2 has a *numeric keypad* on the right side; the keypad contains all the digits; to type a digit, you can use either the numeric keypad or the top row of the main keyboard. The Hazeltine 1400 and the ADM-3A do *not* normally have a numeric keypad; it's an option (and costs extra).

The Hazeltine 1400 and ADM-3A print white characters on a black background. The characters do not blink. The Intertube 2 can print white characters on a black background, but can also print black characters on a white background; and it *can* make the characters blink.

The Hazeltine 1400 can print at 8 speeds:

Characters per second (cps)	Bits per character	Baud (bits per second)
10	11	110
30	10	300
60	10	600
120	10	1200
180	10	1800
240	10	2400
480	10	4800
960	10	9600

The ADM-3A can print at those same 8 speeds, but also at a 9th, faster speed: 1920 cps (19200 baud). The Intertube 2 can print at 15 speeds, ranging from 50 baud to 9600 baud. In practice, most programmers use 960 cps (which throws a whole page on the screen immediately) or 120 cps (which is a nice speed for casual skimming) or 30 cps (which is the fastest speed that an ordinary phone hook-up can transmit).

All those terminals use ASCII and an RS-232C interface.

All those terminals consume little electricity. For example, the Intertube 2 consumes only 27 watts; the Hazeltine 1400 consumes 60 watts. (By comparison, a Decwriter 2 teletypewriter consumes 300 watts when typing, and 160 watts when waiting.

A display terminal is a "better deal" than a teletypewriter:

	Typical teletypewriter	Typical display terminal
Maximum speed	30 cps or 55 cps	960 cps or 1920 cps
Reliability	poor or very good	excellent
List price	$1500-$3000	$850-$995
Power consumed	160 watts or 300 watts	27 watts or 60 watts

Graphics display terminals

If a terminal lets you draw fancy pictures on its screen, it's called a *graphics display terminal*. The Hazeltine 1400, ADM-3A, and Intertube 2 do *not* let you draw fancy pictures; they are *not* graphics display terminals. The best graphics terminals can draw lines, curves, and shaded areas that move, blink, disappear, and change colors. The terminal might come with a special gadget (a *light pen*, *joystick*, *paddle*, *tablet*, or *mouse*) that you hold in your hand and that lets you input your own artistic ideas to the computer. Usually, a graphics terminal is expensive: it costs several thousand dollars.

BUILT-IN KEYBOARDS

Most microcomputers have a keyboard (which looks like the keyboard of a typewriter or teletypewriter or display terminal). Hidden underneath the keyboard is the CPU (the computer's brain) and most of the memory. To send a message to the CPU, type the message on the keyboard.

Video displays

A wire runs from the built-in keyboard to a television set, or to a television monitor. (A television monitor looks like a television set, but doesn't have an antenna, and doesn't have a dial to change stations.) The television set (or television monitor) is called the *video display*.

The keyboard, when combined with the video display, acts like a display terminal: when you type a message on the keyboard, the message appears on the video display; when the computer wants to reply, the computer's reply appears on the video display.

RF modulators

For the video display, if you wish to use an ordinary television set (instead of a television monitor), you must buy a *radio-frequency modulator (RF modulator)*, which is a little box that you clip onto the television's antenna. Run a wire from the keyboard to the RF modulator (*not* directly to the television set).

When you type a message on the keyboard, the keyboard sends the message through the wire, to the RF modulator. The RF modulator turns the message into a radio wave, and transmits it. The radio wave is of the frequency used by television; so the television's antenna picks it up, and makes the television set display the message.

If you use a television monitor (instead of a television set), you don't need an RF modulator: you can run the wire from the keyboard directly to the television monitor.

An RF modulator doesn't work very well: the picture it sends to the television set is fuzzy. (If your RF modulator costs $10, the picture is probably *very* fuzzy; if your RF modulator costs $30, the picture is probably only *slightly* fuzzy.) For a sharper picture, use a television monitor. Or, if you prefer, buy a television set that's specially modified to work with a computer.

Manufacturers

For most microcomputers, the video display is just black-and-white. But some computers can handle color: to get the color, you must buy a color television set or color television monitor.

Here's how the manufacturers compare....

Radio Shack, PET, CBM, Zenith/Heath, Superbrain: a black-and-white monitor is included in the price.

Sorcerer: a black-and-white monitor (or television) is required, but is not included in the price.

Texas Instruments, Compucolor: a color monitor is included in the price.

Apple, Atari: a color monitor (or television) is required, but is not included in the price.

RECEIVE-ONLY PRINTERS

A *printer* is any device that prints on paper. If the printer has a keyboard, it's called a *keyboard send-receive printer (KSR printer)* or teleprinter or teletypewriter; I discussed such printers already. If the printer lacks a keyboard, it's called a *receive-only printer (RO printer)*; I'll discuss such printers now.

You can buy two kinds of RO printers. The cheapest (and slowest) are called *serial printers*: they print just one character at a time. The most expensive (and fastest) printers are called *line printers*: they can print many characters simultaneously.

Serial printers

Most companies that make teletypewriters (such as Teletype, DEC, IBM, TI, Qume, and NEC) also make serial printers. Their serial printers look like their teletypewriters, but don't have keyboards. Since a serial printer doesn't have a keyboard, it costs less than the corresponding teletypewriter; the difference is a few hundred dollars.

Other companies that make serial printers are Radio Shack, Centronics, Anadex, Axiom, Base 2, Integral Data Systems (IDS), Micro Peripherals Incorporated (MPI), Computer Printers International (Comprint), and Okidata (a subsidiary of Japan's Oki Electric Industry Company); those companies do *not* make teletypewriters, but *do* make serial printers; their serial printers use a dot matrix, and print ASCII.

How does a printer work? To print the first line, the printer moves its *print head* across the paper, from left to right; as the print head moves across the paper, the print head puts characters onto the paper. When the print head reaches the right margin, the printer jerks the paper up, and returns the print head to the left margin. If the printer is *bidirectional*, it prints even while returning the print head; so that when the print head has been returned to the left margin, two lines are on the paper. If the printer is only *unidirectional*, it does *not* print while returning the print head; so when the print head has been returned to the left margin, only one line is on the paper. So bidirectional printers are about twice as fast (and more expensive) than unidirectional printers.

For microcomputers, the most popular printer company is Centronics. Radio Shack obtains printers from Centronics, and resells them. Here's what Radio Shack sells:

What Radio Shack calls it	Quick Printer 2	Quick Printer 1	Line Printer 2	Line Printer 1	Line Printer 3
What Centronics calls it	(not from Cen.)	Microprinter P1	Serial Printer 730	Serial 779 + tractor	(not from Cen.)
Radio Shack's list price	$219	$499	$970	$1559	$1960
Centronics' list price	(none)	$495	$995	$1250 + $100	(none)
Electricity consumed	unpublished	40 watts	200 watts	360 watts	85 watts
Speed (cps, or lines per minute)	120 lpm	150 lpm	100 cps	21 lpm; 60-100 cps	120 cps
Maximum paper width	2.38 inches	4.75 inches	9.5 inches	11.5 inches	15 inches
Character width (char. per inch)	9&18 cpi	pica & 5&20 cpi	pica	10 to 16½ cpi	pica & 5 cpi
Maximum characters per line	32 *COMPARE!*	80	80 *COMPARE!*	132	120
Lines per inch	6	5	6	6	adjustable
Size of matrix	5 by 7	5 by 8	7 by 7	5 by 7	9 by 7
Is it bidirectional?	no	no	no	no *COMPARE!*	yes
Can it print lower-case?	yes	yes	yes	no	yes
Can it accept untreated paper?	no	no *COMPARE!*	yes	yes	yes
Can it handle tractor feed?	no	no	no *COMPARE!*	yes	yes
Interface	Centronics	Centronics	Centronics	Centronics	Centronics

Those printers are all *serial* printers, *not* line printers (in spite of Radio Shack's terminology).
Here are some competitors:

Manufacturer	Axiom	Base 2	Comprint	Anadex	MPI	IDS	Okidata	Anadex	IDS
Model	EX-801	800	912	DP-1000	88T	Brighterwriter	Microline 80	DP-8000	Paper Tiger
List price	$445	$499	$560	$570	$749	$799	$864	$995	$995
Characters per sec.	secret	100 cps	225 cps	50 cps	80 cps	50 or 80 cps	80 cps	112 cps	92 cps
Lines per minute	120 lpm	secret	170 lpm	secret	36 lpm	secret	17 lpm	84 lpm	42 lpm
Max. paper width	5 in.	9.5 in.	8.5 in.	3.9 in.	9.5 in.	8.5 inches	10 inches	9.5 in.	9.5 in.
Characters per inch	p.&5&20	5 sizes	11 cpi	elite	8 sizes	pica&elite&16½	pica&5&16½	pica	8 sizes
Max. char. per line	80	132	80	40	132	132	132	80	132
Lines per inch	5	6	6	6	6&8	6	6&8	6	6&8
Size of matrix	5 by 8	5 by 7	9 by 12	5 by 7	7 by 7	7 by 7	7 by 9	9 by 7	7 by 7
Is it bidirectional?	no	yes	no	no	yes	no	no	yes	no
Prints lower-case?	extra $	yes	yes	no	yes	yes	yes	yes	yes
Accepts untreated p.?	no	yes	no	yes	yes	yes	yes	yes	yes
Handles tractor feed?	no	extra $50	no	no	yes	extra $150	extra $	no	yes
Centronics interface?	yes	yes	yes	yes	yes	yes	yes	yes	yes
RS-232C interface?	yes	yes	extra $39	yes	yes	yes	extra $	yes	yes

To decide which serial printer to buy, begin by choosing one of these categories:

Category	Matrix non-impact	Matrix impact	Fully-formed impact
Can print fully-formed char.?	no	no	yes
Can accept untreated paper?	no	yes	yes
List price (for *most* models)	$200-$500	$500-$2000	$2000-$3000
Electricity (for *most* models)	40-60 watts	100-300 watts	100-300 watts
Speed (for *most* models)	70-225 cps	30-120 cps	15-55 cps
Examples	Axiom Comprint Radio Shack "Quick" TI Silent	Base 2 Anadex MPI IDS Okidata Decwriter Radio Shack "Line" TI 800 series Teletype 43	IBM Selectric Qume Sprint NEC Spinwriter Teletype 33
Comments	TI Silent costs more and is slower, but is portable and includes a keyboard.	Decwriter 3 costs more but is quite fast. Radio Shack "Line" Printer 1 consumes more electricity.	Some versions of the IBM Selectric cost less. Teletype 33 costs less and is slower.

If you own an ordinary typewriter, you can turn it into a receive-only printer, by putting a hood over your typewriter's keyboard. The hood contains mechanical fingers, which press the keys. A wire runs from the hood to your computer. Several companies sell the hood; the most active company is Applied Computer Systems; its hood is called the Robotype and costs slightly under $1000.

Line printers

Line printers go faster than serial printers. Since line printers are expensive, microcomputers do *not* use them. Minicomputers use line printers sometimes; maxicomputers use line printers often.

The cheapest decent line printers go at 300 lines per minute (lpm); other line printers go at 600 lpm; the most popular line printers go at 1100 lpm; the fastest traditional line printers go at 2000 lpm; the newest line printers, which use lasers and photograph, are even faster: 20,000 lpm!

ALTERNATIVE PAPER PROCESSORS

Teletypewriters and printers use paper. Here are other devices that use paper....

Punched cards

A *keypunch machine* looks like an electric typewriter; but instead of using paper, it uses *IBM cards*. A traditional IBM card is 7.38 inches long and 3.25 inches high; on the card, you can type 80 characters. Each time you type a character, the keypunch machine type the character onto the card; it also punches holes in the card. The keypunch machine is *not* connected to the computer; the keypunch machine works without the computer.

When you've finished typing a deck of cards, you walk over to the computer's *card reader*, and feed the cards into the card reader's *input hopper*. The card reader looks at the holes in each card; by looking at the holes, it figures out which characters you typed. The card reader is attached to the computer, via a wire; the card reader tells the computer what you typed on each card.

The card reader can read from 200 to 1,200 cards per minute, depending on the reader's quality. When it has read a card, the card reader moves the card from the *input hopper* to the *output hopper*. When the card reader has finished reading the entire deck, the deck is in the output hopper. Take the cards out of the output hopper, and store them on a shelf (or hide them under your bed, or throw them away, or let your dog chew them).

The IBM System/3 minicomputer uses a card that's smaller yet holds more data. The card is only 3.25 inches long and 2.69 inches high, yet holds 96 characters (instead of 80). To hold so much data on such a small card, the holes are smaller and fewer.

A *card punch* is like a keypunch machine: it punches holes in cards. A keypunch machine is run by a human; a card punch is run by the computer instead: the computer punches the cards automatically. It can punch from 45 to 500 cards per minute, depending on the card punch's quality.

Punched-card devices (keypunch machines, card readers, and card punches) are slow, clumsy, and expensive. Most computer centers are getting rid of punched cards. They are buying display terminals instead.

Plotters

A *drum plotter* has a pen that draws on a long roll of paper. For each drawing, you can insert a different pen: pick your favorite color, and pick either ball-point (for fine lines) or felt-tip (for thick lines).

The roll of paper is many feet long (in the X direction) and 11 inches high (in the Y direction). The plotter can nudge the paper in the X direction (.01" to the left or right), nudge the pen in the Y direction (.01" up or down), lift the pen off the paper, and lower the pen back onto the paper: that's all the plotter itself can do. So the only things the plotter can draw are : a .01" horizontal segment (by nudging the paper); a .01" vertical segment (by nudging the pen); and a .014" diagonal 45-degree segment (by nudging the paper and the pen simultaneously). To draw a "curve", you must use a program that repeatedly makes the plotter nudge both the paper and the pen. If you look at the "curve" carefully, you'll see it is really made of tiny segments, each .01" or .014" long.

Some plotters are more accurate (.001" instead of .01").

A *flat-bed plotter* resembles a drum plotter, but draws on a large flat sheet of paper instead of on a narrow roll.

The most famous manufacturer of plotters is California Computer Products (Calcomp).

Most computer centers are getting rid of plotters and are switching to graphics display terminals, because graphics display terminals draw more quickly and are becoming cheaper.

What's the best way to make the computer produce an artistic picture on paper? Until recently, the answer was: use a plotter. But now, the answer is becoming: use a graphics display terminal, and take a photograph of its screen (by using an ordinary camera).

Scanners

An *optical scanner* shines a light at a piece of paper, and reads what's on the paper. For example, it can examine photographs and paintings.

If it's specifically designed to read letters and numbers (instead of pictures), it's called an *optical character-recognition reader (OCR reader)*. For example, the post office uses OCR readers to read ZIP codes on mail.

If the optical scanner detects only squares that a pencil has darkened (as on a College Board test), it's called an *optical mark-recognition reader (OMR reader)*.

In some modern supermarkets, every package has a code on it; the code consists of vertical lines having different thicknesses and spacing. That's called the *Universal Product Code (UPC)*. When you decide which packages you want to buy, and you bring them to the check-out counter, the cashier waves a *wand* over the packages— or pulls them through a slot that contains a wand. The wand is a tiny optical scanner; it reads the UPC on the packages. A wire runs from the wand to the supermarket's computer, so the computer finds out what you've bought. Using that information, the computer figures out your bill, and also adjusts the store's inventory, so that the store's manager knows which items to stock up on.

At the bottom of a bank check, you'll see funny little numbers, printed in black. To print those numbers, the bank uses *magnetic ink* (ink that contains magnetic particles). To read those numbers, the bank uses a *magnetic-ink character-recognition reader (MICR reader)*. The MICR reader reads only characters written in magnetic ink; so if you try to add an extra digit, by using an ordinary pen or pencil, the MICR reader won't read it, and your "forgery" won't make any difference.

AUDIO

Can the computer make sounds? Can it sing? Can it talk? Can it hear your voice?

Traditional methods

The easiest way to get the computer to "make sounds" is to pre-record the sounds on a tape recorder, and program the computer to turn the tape recorder on and off.

A more sophisticated way is to pre-record some sounds on a tape recorder, and then transfer the sounds from the tape to the computer's main memory (by running a wire from the tape recorder to the computer's main memory). Though the computer's main memory can't actually store a "sound", it can store a code that *represents* the sound. Turning the sound into a computer code is called *digitizing the sound*; the code that represents the sound is called the *digitized sound*. When the digitized sound is in the computer's main memory, you can program the computer to fiddle with the digitized sound, and then send it back to the tape recorder. The result: the tape recorder starts playing sound that's been fiddled with. It's more interesting to hear than the original sound.

Instead of pre-recording the sound, you can attach the computer directly to a microphone. Then you can talk into the microphone; the computer will analyze what you say, and will obey your command. To make all that happen, you must write a program that explains to the computer how to analyze your voice. Writing that program is tough.

Built-in speakers

The Apple microcomputer contains a speaker that can make a very fast sound. The sound is a "click", so fast and brief that you can hardly hear it. You can program the Apple to make a click, then a pause, then a click, then a pause, etc., repeatedly, so quickly that your ear can't hear the clicks and pauses: it hears just a whirring sound. By changing the lengths of the pauses, you can change the pitch of the whirring sound: in other words, you can make the whir sound be a high note or a low note. By fancy programming, you can make the computer produce such whirring notes and combine them to form music. You can buy a program that makes the Apple even produce four-voice harmony.

Newer microcomputers (such as the ones by Atari, Texas Instruments, and APF) have the music built in, so the programmer doesn't have to compute lengths of pauses and numbers of clicks.

Radio

Every computer makes a high-frequency hum when it's "thinking". The frequency is too high for your ear to detect; in fact, the frequency is about the same as a radio wave. So if you put an ordinary radio near the computer, and put the radio's dial halfway between two stations (so that you hear neither), you'll hear the computer's thinking instead: the radio will play the computer's hum so you can hear it. Because the computer's hum is so strong, and because the computer thinks at so many different levels, you can hear the hum on both AM and FM: keep turning the radio's dial, until you find a place on the dial where the hum sounds pretty. As the computer thinks about different topics (addition, subtraction, multiplication, etc.), its hum changes pitch— because some topics are harder than others. Into the computer, feed ordinary programs (about math or science or business or games), and listen to what comes out of the radio. You'll have fun listening to the computer's "brainwaves".

Programmers have figured out how to feed the computer a program that makes the computer's brainwaves change speed in exactly the right way so that the radio plays "Mary Had a Little Lamb" and other popular tunes.

Music synthesizers

Many rock musicians— and straight musicians— use *music synthesizers*. A music synthesizer is a machine that produces music— and other weird sounds; the machine has many dials on it, and usually comes with a piano-style keyboard. The machine also comes with *patch cords*, which are wires that come out of the machine and plug into various holes in the machine. To change the sounds the machine makes, you turn the dials, tap the keys on the keyboard, and plug the patch cords into different holes. The machine does *not* require a computer; but if you wish, you can plug some of the cords into the computer, so that the computer has some control over the music.

The two most popular music synthesizers are the Moog and the Arp. Full-size models are expensive; smaller ones (the "Mini-Moog" and Arp's "Odyssey") cost about $1300; the newer "Micro-Moog" costs about $550. You must also buy amplifiers and speakers.

Voice synthesizers

A *voice synthesizer* is a device that can pronounce vowels and consonants. It must be attached to a computer; the computer tells it which vowels and consonants to pronounce. You can program the computer to make the voice synthesizer say vowels and consonants that make a whole word, or a whole sentence, or a whole paragraph. So by stringing the vowels and consonants together, you can make the voice synthesizer talk.

The most popular voice synthesizer is the Votrax, manufactured by a company called the Federal Screw Works. The Votrax comes in many models. The cheapest (and worst) model of the Votrax is sold by Radio Shack for $399; that price includes all the equipment: the phonetic electronics, the amplifier, and the speaker. That model pronounces the vowels well, but has trouble with some of the consonants: it sounds like it has a cold. It talks in a high-pitched male monotone. Fancier models of the Votrax are much better: they can handle consonants decently, and can vary the inflection (pitch), so that they sound less monotonous and more human.

Another popular voice synthesizer is the Computalker, manufactured by Computalker Consultants. It costs about the same as the cheapest Votrax, and sometimes sounds slightly better.

The highest quality voice synthesis is done by the Kurtzweil Reading Machine. It reads books to the blind. To use the machine, you just lay the book on what looks like a Xerox machine; it's really an optical scanner. Using the scanner, the computer looks at the book, analyzes the typeface and the page's layout, figures out what the letters and words are, finds (by looking at a table) how to pronounce the words, and pronounces them by using a high-quality voice synthesizer that has a deep baritone voice. (The previous model of the Kurtzweil Reading Machine had a high-pitched Swedish accent instead, which wasn't as good.) The computer analyzes the structure of the sentence, and makes the synthesizer raise and lower its pitch at the right places in the sentence. The price of the entire machine (including the optical scanner, computer, voice synthesizer, and programming) is $19,000. The machine talks clearly and enjoyably, faster than a human. It's been used by many libraries and organizations for the blind. Its inventor, Raymond Kurtzweil, has been praised by the U.S. Government— he demonstrated his machine at a session of Congress— and he won an award from the national computer organization (the Association for Computing Machinery). The most amazing thing about the machine is that it's so easy to use: just put the book down on the optical scanner, and— presto!— the computer reads the book in a cheery enjoyable voice. You don't have to tell the computer anything about the book's typestyle or layout.

WHAT TO BUY

Which I/O devices should you buy? The answer depends on how much money you're willing to spend, and what you want the computer to do.

If you have very little money, get a microcomputer that has a built-in keyboard; and then, if you can spend a few extra bucks, add a receive-only printer. You don't need to buy a display terminal; instead, use the built-in keyboard combined with the video. You don't need to buy a teletypewriter; instead, use the built-in keyboard combined with the receive-only printer.

That proves: if your computer has a built-in keyboard, you can save lots of money.

If your computer does *not* have a built-in keyboard, your options are different; here they are....

Option 1: buy a display terminal. Advantages: it's cheap and quick. Disadvantage: it doesn't hand you a piece of paper.

Option 2: buy a teletypewriter. Unfortunately, it's slightly more expensive and slower than option 1. But it *does* give you a piece of paper!

Option 3: buy a display terminal, plus a device that uses paper (either a teletypewriter or a receive-only printer); and switch back-and-forth between them. This is expensive, but allows you to get high speed *and* paper output.

If *many* people want to use the computer simultaneously, your best bet is usually to give each person a display terminal, and let the whole group share one device that uses paper (either a teletypewriter or a receive-only printer). If the group is *very* large, a single paper device might not be enough; instead, buy *several* teletypewriters, plus one super-fast receive-only printer.

COMMUNICATIONS

Suppose you're in your own home or school or office, and you want to use somebody else's computer, which is many miles away. Here's how....

In your own home (or school or office), install a display terminal or teletypewriter, and attach it to an *acoustic coupler*, which is a box that makes beeping noises. Using an ordinary telephone, dial the computer's phone number. When the computer responds (by making a hum), put your telephone's receiver onto the acoustic coupler, so that the coupler beeps into the telephone. To communicate with the computer, type on your display terminal (or teletypewriter), which will transmit the message to the acoustic coupler, which will beep the message into your telephone, which will transmit the message to the computer's telephone, which the the computer will listen to. That's how to send a message to a computer that's far away. When the computer wants to reply, it will beep a message into its phone, which will be transmitted to your phone, which your acoustic coupler will listen to and pass on to your display terminal (or teletypewriter), which will put the message onto your screen (or paper), so you can read it.

Notice that the acoustic coupler can perform *two* tasks: it can send a message from your display terminal (or teletypewriter) to your telephone (by beeping), and it can send a reply from the telephone back to your display terminal (or teletypewriter). So the acoustic coupler is a two-way device.

An acoustic coupler is an example of a *modulator/demodulator (modem)*, which means: a device that converts back and forth between two kinds of electrical signals (modulated signals and demodulated signals). If somebody offers to sell you a "modem", he probably means he's selling, more specifically, an acoustic coupler; but to be sure, ask.

Typically, when you communicate with the computer via telephone, you transmit 30 characters per second (300 baud); and the computer's reply comes at the same speed. To increase the speed to 120 characters per second (1200 baud), you have two choices: get either a special phone line or a special acoustic coupler.

Most programmers like display terminals better than teletypewriters, because display terminals are faster. But if your phone line and acoustic coupler transmit only 30 characters per second, your display terminal will run very slowly, so you might as well get a teletypewriter instead.

Memory

TERMINOLOGY

When you buy memory, you must ask two questions: "How fast is it?" and "How much can it hold?"

Measurement

The memory's speed is measured in these units....

A *millisecond* is a thousandth of a second.
A *microsecond* is a millionth of a second; it is a thousandth of a millisecond.
A *nanosecond* is a billionth of a second; it is a thousandth of a microsecond.

A thousand nanoseconds make a microsecond; a thousand microseconds make a millisecond; a thousand milliseconds make a second.

The abbreviation for *second* is *sec*. The abbreviation for *millisecond* is *msec* or *ms*. The abbreviation for *microsecond* is supposed to be *μsec* or *μs*; the symbol μ is pronounced "mew" (as if it were a pussy); it is a Greek letter, and is sometimes written "mu". If you're typing a note to another programmer, and your typewriter doesn't have the symbol μ, type the letter *u* instead; the programmer will figure out what you mean. The abbreviation for *nanosecond* is, of course, *nsec* or *ns*.

The memory's quantity is measured in these units....

A *byte* is a character.
A *kilobyte* is a thousand bytes. It's approximately the amount you can fit on a double-spaced typewritten page having wide margins.
A *megabyte* is a million bytes; it's a thousand kilobytes. It's approximately the amount in a 300-page "pocket-size" paperback.
A *gigabyte* is a billion bytes; it's a thousand megabytes. So it's approximately the amount in a thousand 300-page paperbacks.

The abbreviation for *kilobyte* is *K*; the abbreviation for *megabyte* is *M*; the abbreviation for *gigabyte* is *G*.

For example, if you buy a *16K memory*, you've bought a *16-kilobyte memory*; so you've bought a memory that holds at least 16,000 bytes. You've bought a memory that's large enough so that it can remember 16,000 characters.

That's the terminology used by *most* manufacturers; and that's the terminology I'll use in this book. But on old-fashioned computers, the memory is sometimes measured in *words* instead of *bytes*. A *byte* is one character; a *word* is *several* characters:

Old-fashioned computer	Definition of a word (approximately)
PDP-8, PDP-11	2 characters
PDP-10, PDP-20	5 characters
CDC	10 characters

For those computers, if somebody offers to sell you a "16K memory", the person might mean 16,000 *words* instead of 16,000 *bytes*; ask!

Two activities

You can do two things to the memory....

1. You can find out what information is in the memory. That's called *reading the memory* or *peeking at the memory* or *retrieving from the memory* or *loading from the memory*.

2. You can put new information into the memory. That's called *writing into the memory* or *poking at the memory* or *storing in memory* or *saving in memory*.

Main & auxiliary

The CPU (the computer's brain) thinks quickly. When it wants to remember information, it shoves the information into the memory. When it wants to retrieve that information, it asks the memory to spit that information back.

If the memory works slowly— if it grabs information from the CPU slowly, and spits the information back to the CPU slowly— the CPU will have to wait. Instead, you should buy memory that works as quickly as the CPU can think.

But unfortunately, quick memory is expensive. So most computers have two kinds of memory: a small amount of quick, expensive memory (which contains information the computer needs immediately), and a large amount of slower, cheaper memory (which contains all the information the computer won't need until later, or need rarely, or perhaps never use at all). The quick, expensive memory is called *main memory*; the slow, cheaper memory is called *auxiliary memory* (or *secondary memory*). You'll want both. Buying 100% main memory is too expensive; buying 100% auxiliary memory is too slow; you'll probably want to buy 10% (or less) main memory, and 90% (or more) auxiliary memory.

Main cabinet

Because the CPU must grab the main memory immediately, the main memory is usually located next to the CPU; the auxiliary memory is farther away. Usually, the metal cabinet that contains the CPU also contains the main memory; that cabinet is called the *CPU cabinet* or *main cabinet* or *mainframe*. (Warning: the word *mainframe* has two contradictory definitions: some people define *mainframe* to mean *main cabinet*, but other people define *mainframe* to mean *maxicomputer*. To avoid confusion, I recommend that you never use the word *mainframe*.) If somebody offers to sell you a "CPU cabinet", find out whether the price includes the main memory, or just the CPU, or just an empty metal cabinet that you have to fill up yourself! Another confusion: some people say "CPU" instead of "CPU cabinet"; so if somebody offers to sell you a "CPU", find out whether the price includes just the CPU itself, or also includes the whole CPU cabinet, including even the main memory. Moral: whenever anyone in the computer industry offers to sell you anything, ask lots of questions, to find out what the salesman really means.

A typical computer system therefore consists of a big metal cabinet (which contains the CPU and main memory), plus many smaller devices (which are scattered around the room). Some of those smaller devices are for I/O; others are for holding auxiliary memory. Those small devices— for I/O and for auxiliary memory— are called *peripherals*. So computer hardware falls into two categories: the items in the main cabinet, and the peripherals. If someone says he's selling a "complete computer", his price might include just the items in the main cabinet; find out whether he's also including the peripherals.

MAIN MEMORY

In most modern computers, the main memory consists of many flat pieces of metal. Each flat piece of metal is called a *semiconductor chip*, and is small: about an eighth of an inch on each side. Etched into the tiny chip is a complicated electric circuit; the chip is called an *integrated circuit (IC)*. Electrical patterns in the chip represent the represent the information the memory is storing.

The chip hides inside the belly of what looks like a black caterpillar: the "caterpillar" is typically 1.3 inches long, .6 inches wide, and flat ("squashed"). It typically has 12 pairs of legs; so it has 24 legs altogether. The "caterpillar" is called a *dual in-line package (DIP)*. Usually it is plastic and lets the chip work when the temperature is anywhere from 0°C to 70°C (32°F to 158°F). If the temperature is much colder or much hotter, you need a DIP that's ceramic instead of plastic.

The caterpillar's legs are metal, and are called *pins*. Inside the caterpillar, a wire runs from each pin to the chip in the belly; each wire is like a "nerve". When the chip wants to send out a message, it sends the messages through its "nerves", to its "legs" (pins). The legs do not move; however, if you run long wires from the legs to the CPU, the CPU can find out what the chip is trying to say.

So to create the main memory, you can buy lots of "caterpillars", and run wires from their legs to the CPU. But stringing all those wires is complicated; you'll probably goof, and attach the wrong wire to the wrong pin. Instead of stringing wires, most computers use this simpler method....

The "caterpillars" are mounted on a green board. The legs of each caterpillar touch the board. The board is mostly green plastic, but on top of the plastic is printed a diagram. The diagram is printed in metal instead of in ink. The diagram is an electrical circuit. It contains a line that goes from each caterpillar's leg to the CPU. The lines of the diagram act just like wires; but since the lines are pre-printed on the board, you don't have to "string" a lot of wires. The board—including the diagram on it—is called a *printed-circuit board (PC board)*. A board can hold several dozen caterpillars. If you need more caterpillars, buy extra boards.

Kinds of chips

Chips come in two varieties: *RAM*, and *ROM*.

The *RAM* chips are the most flexible and the most popular. You can write information into them, and read information from them. The letters "RAM" stand for "Random-Access read-write Memory". Usually, the RAM-chip "caterpillars" sit in rows; each row contains 8 caterpillars. Altogether, the row contains 16,384 bytes. (That's close to 16,000 bytes; to be brief, most salesmen say that the row holds "16K".) Therefore, when you buy RAM, the amount of memory you get is usually a multiple of 16,384 bytes. You can buy 16K, or twice as much (which is 32K), or twice as much again (which is 64K), etc. These quantities are popular:

16K (actually 16,384 bytes)
32K (actually 32,768 bytes)
64K (actually 65,536 bytes)
128K (actually 131,072 bytes)
256K (actually 262,144 bytes)
½M (actually 524,288 bytes)
1M (actually 1,048,576 bytes)
2M (actually 2,097,152 bytes)
4M (actually 4,194,304 bytes)
8M (actually 8,388,608 bytes)

If you buy a small microcomputer for your home, the RAM is probably just 16K. If you're using the microcomputer for business, the RAM is probably 32K (in other words, 2 rows of "caterpillars"). If you have a super-fancy microcomputer, or a minicomputer or maxicomputer, you probably have much more RAM than that.

When you unplug the computer, the RAM forgets all the information you had stored in it. The same thing happens if your town has a blackout.

ROM is less flexible than *RAM*. A ROM chip contains information that you *cannot* change; the information is etched into the chip permanently. The information remains in the ROM chip even if the power goes off. The letters "ROM" stand for "Read-Only Memory"; you can read the information in the ROM, but you cannot alter it. When you buy a computer, the computer probably already includes ROM chips, which have been etched by manufacturer. Programmers say that the information in the ROM chip has been *burned in*, by the manufacturer. A typical ROM chip holds 4K.

A typical computer contains many RAM chips, plus a few ROM chips. The RAM's caterpillars are arranged in rows; the ROM's caterpillars are not. So whenever you see a row (or several rows) of caterpillars, you know those caterpillars contain RAM, not ROM.

When you buy a RAM, it's blank; into the RAM, you stash whatever information you please. When you buy a ROM, it *already* contains information (which you cannot change); ask the salesman what information it contains.

RAM and ROM chips work quickly. In a typical microcomputer, reading or writing a byte requires only a quarter of a microsecond (in other words, 250 nanoseconds). Larger computers go even faster.

You can buy two kinds of RAM. The most popular kind is called *metal-oxide semiconductor field-effect transistor RAM (MOSFET RAM, or simply MOS RAM)*. The other kind, *bipolar RAM*, is faster but more expensive. If your computer is a micro, it has only the cheap kind (MOS). If your computer is a mini or maxi, it has mainly MOS but might also have some bipolar, which increases the speed (and the price).

Cache

In large IBM maxicomputers, the memory comes in two parts: one part is large (½M to 8M) and slow (MOS, 300 nanoseconds); the other part is small (8K to 64K) and fast (bipolar, 50 to 100 nanoseconds).

The small, fast part is called the *buffer storage unit* or *cache*. The large, slow part is divided into *blocks*; each block holds 32 bytes. To use a block, the CPU puts a copy of it into the cache, and then uses just the copy in the cache, which can be accessed more quickly than the original. To use information from a different memory block, the CPU copies that block into the cache also: the cache is large enough to hold copies of hundreds of blocks.

So to get information from the memory, the CPU first checks whether the block that contains the information has already been copied into the cache. If it has, the CPU uses the copy in the cache, instead of the original block. But if the block has *not* been copied into the cache, the CPU must copy it.

If you want to revise some information in the memory, the CPU revises the information in the cache, and also revises the original block in the main memory, so that the cache still contains an exact copy of what's in the block.

Suppose the CPU tries to copy another block into the cache, and the cache is already full. Then the CPU must erase part of the cache, to make room for the new copy. The CPU erases the part of the cache that's been used the least recently. (The CPU keeps track of how recently each part of the cache has been used.)

Other large computers have caches also:

Computers	Size of cache	Size of block	Cache access time
large IBM maxicomputers	8 to 64 kilobytes	32 bytes	50 to 100 nanoseconds
PDP-20 (model 60)	10 kilobytes	18 bytes	160 nanoseconds
PDP-10 (model KL)	10 kilobytes	18 bytes	300 nanoseconds
VAX 11 (model 780)	8 kilobytes	8 bytes	200 nanoseconds
PDP-11 (model 70)	2 kilobytes	4 bytes	300 nanoseconds

For all those computers, the *hit rate* is about 90%. That means: when the CPU wants to use information from memory, the probability is 90% that the information is already in the cache, and the CPU doesn't have to copy another block from the slow memory.

Prices

I said that MOS RAM is cheap. Its exact price depends on who you buy it from. IBM's new low price is: $15,000 per megabyte. That price includes the MOS RAM "caterpillars", the PC boards on which they're mounted, other required circuitry, etc. That price is for IBM 4331 and IBM 4341 maxicomputers.

For microcomputers, many discount houses will sell you 16K of MOS RAM "caterpillars" for about $80 (some places charge as little as $65). But since that price includes just the "caterpillars", you must already own the PC board on which to mount them, and you must be willing to mount them yourself.

Jargon

When talking to a salesman, do *not* ask for "caterpillars"; he won't know what you're talking about. Instead of asking for a "caterpillar", use the official name: ask for a "DIP". Or, to be more chatty, ask for a "chip" or "IC"; he'll automatically assume you want the chip to be enclosed in a DIP. Instead of asking for "16K of caterpillars", or "16K of DIPs", most programmers ask for "a 16K chip set", which usually means a row of 8 DIPs, containing chips, and holding 16 kilobytes altogether.

Cartridges

Typically, the ROM "caterpillars" are mounted on the same PC board as some of the RAM "caterpillars". But for the newest low-cost microcomputers (by Exidy, Texas Instruments, and Atari), the PC board that contains the ROM is *different* from the PC board that contains the RAM; and the PC board that contains the ROM comes in a *cartridge*, which you can pop in and out of the computer, as easily as you pop cassettes in and out of a stereo system. In less than two seconds, you can pop out one ROM cartridge, and pop in a different ROM cartridge instead. Each ROM cartridge contains a different program, or a different programming language. By switching cartridges, you change what the computer "knows".

Unfortunately, the term "ROM cartridge" is not glamorous. Instead, Exidy (which makes the Sorcerer computer) calls it a "ROM Pac"; and Texas Instruments calls it a "Solid-State Software Command Module"; both of those terms are trademarked. Atari is more modest, and simply says "ROM cartridge".

The price of a ROM cartridge depends on what kind of information the ROM contains. Atari charges $50 for a cartridge that contains a game program, and $70 for a cartridge that contains something more serious. Texas Instruments' cheapest cartridge costs $20; its most expensive costs $70. Exidy usually charges $99.

Atari does a similar thing for RAM: Atari sells RAM cartridges, which it calls "RAM modules". If you want extra RAM, you buy a "RAM module" and pop it in. An 8K RAM module costs $125; a 16K RAM module costs $250; you can pop in several RAM modules simultaneously.

Cores

Old computers use *cores* instead of chips. *Cores* are doughnuts, made from a chemical compound that includes iron. In a typical old computer, the main memory has several *million* cores, and each core is very small: the diameter is either .013 or .018 inches. Through the core's hole go 3 wires; all the cores are strung onto the wires. When electricity runs through the wires, the cores get magnetized, because the cores contain iron. The direction in which the electricity runs through the wires affects the direction of each core's magnetic field. The magnetic fields represent the information the memory is holding.

To store a byte of information, you need about 8 cores. So to store 16K bytes, you need about "16,000 times 8" cores, which are 128,000 cores. By contrast, to store the same amount of information by using semiconductor chips, you need only one row of 8 chips. Stringing wires through 128,000 cores is much harder than wiring 8 chips; so using cores is more expensive and less popular than using chips.

AUXILIARY MEMORY

The two most popular kinds of auxiliary memory are: *tapes* and *disks*. A *tape* looks like the kind of tape that teenagers use for playing music. A *disk* looks like a phonograph record.

The tape or disk is covered with "ferric oxide" (rust); so the tape or disk looks brown or orange. Because the rust contains iron, it can be magnetized. To magnetize it, you put the tape or disk into a machine that's called a *drive*. (You put a tape into a *tape drive*; you put a disk into a *disk drive*.)

The drive contains a motor, that spins the tape or disk. While the tape or disk spins, a *read/write head* moves near it. The read/write head is part of the drive. An electric current flows through the drive and through the read/write head. Because the read/write head is close to the tape or disk, and because electricity is flowing through the read/write head, and because the tape or disk contains iron, the electric current magnetizes the iron. The direction in which the electricity flows affects the direction in which the iron is magnetized. By changing the direction of the electricity, you create patterns of magnetic fields on the spinning tape or disk. Those patterns form a code, which represents the information that the tape or disk is storing.

When you've finished putting magnetic fields onto the tape or disk, you can remove the tape or disk from the drive, and store the tape or disk on a shelf, somewhere else in the room. The tape or disk will remain magnetized. You can turn off the computer, turn off the drive, and walk away: the information will remain on the tape or disk, undestroyed (unless your enemy puts a magnet next to the tape or disk).

In the future, whenever you wish, turn the drive on again, take the tape or disk off the shelf, insert the tape or disk into the drive, and tell the drive to "read" the tape or disk. Inside the drive, the tape or disk will spin again, and the read/write head will move near the tape or disk again. But this time, the procedure works backwards: instead of having the read/write head's electric current magnetize the tape or disk, the tape or disk's magnetic field creates a current in the read/write head. The direction of the magnetic field affects the direction of the current. The current goes from the read/write head through the drive and to the rest of the computer, so that the computer finds out what was on the tape or disk.

A tape or disk is called a *medium*. To use auxiliary memory, you need two items: a medium, and a drive.

The medium is cheap; the drive is expensive. The cheapest tape costs about $1; the cheapest tape drive costs about $30. The cheapest disk costs about $3; the cheapest disk drive costs about $300.

Tapes versus disks

Tapes cost less than disks, and tape drives cost less than disk drives. So if you have very little money, buy just one tape drive, and pop many tapes in and out of it.

If you have more money, get a disk drive instead of a tape drive. (A disk drive works more quickly than a tape drive.) Pop many disks in and out of the disk drive.

If you have *lots* of money, buy *several* disk drives, or buy a few disk drives and a few tape drives.

Here's why a disk drive works more quickly than a tape drive....Suppose you want to retrieve some data that's in the middle of a tape. To get to the right place on the tape, you must read all the stuff that comes before it— and perhaps press the "fast forward" button occasionally. To get to the middle of a disk is much easier: the typical disk drive's read/write head is mounted on an arm, which can move immediately to the middle of the disk.

So if you need to skip to the middle of your data, a disk will work faster than a tape. On the other hand, if you want to go through all the data in order— beginning at the beginning, and ending at the ending— a tape is about as quick as a disk. (The exact speed depends on which computer and tape drive you buy.)

Going through the data in order is called *sequential order*; skipping is called *random access*. A disk drive can handle random access more quickly than a tape drive. For sequential access, both kinds of drives work about equally well (again, the exact comparison depends on which computer and tape drive you buy).

Mechanical motion

The speed at which you can get information from disk or tape depends on how fast the disk or tape spins. For a disk, its speed also depends on how fast the drive's arm moves. So auxiliary memory's speed depends on how fast object move.

By contrast, in *main* memory no object moves. Neither the "caterpillars" nor the "cores" move. In main memory, the only things that move are electrons. So in main memory, the speed at which you can retrieve information is "electronic"— the speed of light. In auxiliary memory, the speed is less, and depends on how fast the drive's motor can do mechanical motion: spin the media and move the head.

Summary: the main memory is fast, because it's *purely electronic*; the auxiliary memory is slower, because it's *electro-mechanical*.

In the past, main memory was much more expensive than auxiliary memory. But since main memory is purely electronic, its price is decreasing more rapidly than the price of auxiliary memory. Main memory still costs more (per byte) than auxiliary memory— but not by much.

Controllers

To attach a drive to the rest of the computer, you need a *cable* (which is a bunch of long wires) and a *controller* (electronic circuitry that controls the drive, and acts as an intermediary between the drive and the computer). Usually, a tape controller can handle eight tape drives; a disk controller can handle four disk drives. So if you want to buy a ninth tape drive, or a fifth disk drive, you must buy an additional controller.

Kinds of tape drives

You can buy four kinds of magnetic-tape drives:

1. An *audio cassette tape drive* is an ordinary cassette tape recorder— the same kind that teenagers use, for listening to music.
2. A *digital cassette tape drive* looks like an audio cassette tape drive, but lacks a microphone. It is made specially for use with a computer. It handles computer data more quickly and more accurately than an audio cassette tape drive. It is also more expensive.
3. A *cartridge tape drive* looks like a digital cassette tape drive, but the cartridge's shape is different from the shape of a traditional Philips cassette. The cartridge's special shape lets even more data squeeze onto the tape, lets the drive hande the data even more quickly, and lets the tape maintain its high quality even longer.
4. A *reel-to-reel tape drive* is the most expensive, the fastest, and holds the most data. It uses huge reels of tape, instead of tiny cassettes or cartridges. It's the kind of tape drive you see in science-fiction movies.

Of those four choices, which is the best?

Choice #1 is slower than choice #2, which is slower than choice #3, which is slower than choice #4. Choice #1 holds less data than choice #2, which holds less data than choice #3, which holds less data than choice #4. Choice #1 is cheaper than choice #2, which is cheaper than choice #3, which is cheaper than choice #4.

Choice #1 is used in the cheapest microcomputers. Choices #2 and #3 are used in expensive microcomputers and in the cheapest minicomputers. Choice #4 is used in expensive minicomputers and in maxicomputers.

Choices #1 and #4 are the most popular. Choice #1 is used by people who have low-cost microcomputers in their homes, and who don't have enough money to buy even the cheapest disk drive; they buy choice #1 instead.

Choice #4 is used in huge computer centers, for the "archives". The *archives* are piles of data that are relatively unimportant and used very rarely, but which cannot quite be thrown away. For example, the archives include *last* year's records. The computer center copies the archives from the big disks (on which they were originally created) to the big tapes, which are much cheaper than the disks; the disks are then erased and re-used for information of greater importance.

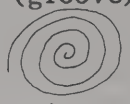
Choice #4 is also used for "fail-safe backup". If a disk contains important information, and you're afraid that the disk might accidentally get destroyed (because of a fire or a programmer's error), copy the disk's information onto a tape, and hide the tape far away from the disk. So if the disk ever gets wrecked, you can still retrieve the information— from the *fail-safe backup tape*.

How many bytes can you fit on a tape? How fast can you transfer information between the computer and the tape? How much does a tape cost? How much does the *drive* cost? The answers depend on which model you buy. Here are some typical models:

Model	Capacity	Transfer rate	Prices (rounded)	
			Drive	Tape
an audio cassette that uses 1 track for 30 minutes at 500 baud	112.5 kilobytes	62.5 bytes/sec	$40	$2
a digital cassette that uses 1 track at 20 inches per second	360 kilobytes	2 kilobytes/sec	$800	$7
a digital cartridge made by 3M Corp. and called the DC-300A	2.3 megabytes	6 kilobytes/sec	$1000	$15(?)
a reel-to-reel that uses 9 tracks at 1600 bits per inch, 75 inches per sec.	46.1 megabytes	120 kilobytes/sec	$7000	$12

MORE ABOUT DISKS

Disks are the most convenient form of auxiliary memory. A disk looks like a phonograph record, but here are some differences:

Phonograph record	Disk
black	brown or orange
spins at 33, 45, or 78 rpm (revolutions per minute)	spins at 300, 360, or 3600 rpm
the track (groove) is a spiral 	each track is a circle
the machine is called a *phonograph*	the machine is called a *disk drive*
you put the record *on* the turntable	you put the disk *in* the drive
the arm contains a *needle*	the arm contains a *read/write head*

Kinds of disks

A disk can be *two-sided* (like a phonograph record) or *one-sided* (which means the flip side is blank).

The disk's diameter can be 5, 8, or 14 inches.

The disk can be *hard* (like a phonograph record) or *floppy* (which means the disk is so thin you can bend it; but do *not* bend it!). Floppy disks are small: the diameter is either 5 or 8 inches. Hard disks are usually large (14 inches), but 8-inch hard disks are available also.

Because a floppy disk is small and thin, IBM calls it a *diskette*. A 5-inch floppy disk is sometimes called a *Minidiskette* or *Minifloppy*; those terms are trademarked by Shugart.

Usually, a 5-inch floppy disk holds less information than an 8-inch floppy disk, which holds less than an 8-inch hard disk, which holds less than a 14-inch hard disk. Disks that hold little are usually cheaper and slower than disks that hold a lot.

5-inch floppy disks are used on microcomputers. 8-inch disks (floppy and hard) are used on microcomputers and the smallest minicomputers. 14-inch hard disks are used on maxicomputers and the largest minicomputers.

A disk can be either *removable* or *non-removable*. If it's *removable*, you can remove it from the disk drive— just as you can remove a phonograph record from a record player. But if the disk is *non-removable*, you can*not* remove it from the disk drive, and so it must remain in the disk drive forever. All floppy disks are removable. Most hard disks are removable, but some are not.

Packaging

Like a phonograph record, a floppy disk comes in a square *jacket*, which protects the disk from scratches and dust. The jacket is made of a material whose outer surface is a thin piece of black cardboard, and whose inner cotton-like surface wipes the disk as the disk spins.

To use a phonograph record, you remove its jacket. But to use a floppy disk, you do *not* remove the jacket; instead, the jacket has a slit in it; the disk drive's arm pokes through the slit, to get to the disk. So even while you're using the disk, the jacket remains on the disk, and continues to protect it.

Although a floppy disk has a jacket, a hard disk does not. Instead of a jacket, a removable hard disk comes in a *cartridge* or a *pack*. A *cartridge* is similar to a jacket, but is round (instead of square), sturdy plastic (instead of flimsy cardboard), contains a trap door (instead of a slit), and doesn't touch the disk (instead of wiping it). A *pack* is a whole stack of disks, arranged on a *spindle* that goes through their centers; the stack is covered by a clear plastic cylinder, which you can remove.

Head motion

A phonograph record lies horizontally on a turntable. Similarly, in most disk drives, the disk lies horizontally. But some disk drives are positioned upright, so that the disk is vertical.

Here's how to get information from the top side of a typical horizontal disk. First, you must move the arm across the disk, until the read/write head (which is mounted on the arm) is above the correct track of the disk.

Then, if the disk is floppy, you must lower the head, until it touches the disk. But if the disk is hard (instead of floppy), you do *not* have to lower the head: instead, the head's already close enough to the disk so that it can sense the directions of the disk's magnetism.

If your hard-disk drive is ultra-modern, the head acts as a miniature airplane: it *flies* above the disk. It flies at a very low altitude: a tiny fraction of an inch. The only thing keeping the head off the rotating disk is a tiny cushion of air— a breeze caused by the disk's motion. When you unplug the disk drive, the disk stops rotating, so the breeze stops, and the head comes to rest on a *landing strip*, which is like a miniature airport. Such a disk drive is called a *flying-head drive*. The first flying-head drive was invented by IBM; when the drive was still top-secret, IBM's code name for it was "Winchester". Today, IBM and many other companies sell such drives, which are still called *Winchester drives*.

So to get information from a typical disk, the first step is to move the head to the right track. That motion takes time; you must wait.

To eliminate the wait, some disk drives have *many* heads on the arm; each track has its own head. The heads and arm are stationary, and never have to move. That's called a *fixed-head disk drive*. It's super-quick, but also super-expensive, since it contains so many heads. The cheaper kind of disk drive— the kind that's *moving-head*— is more popular. All floppy-disk drives are moving-head. Only the largest, most expensive maxicomputers use fixed-head drives; such a huge computer has one or two fixed-head drives, and many, many moving-head drives. The fixed-head drive contains the information that's most important, used most often, and needed most quickly.

If you have a moving-head drive, how long does the head take to move? That depends on where the head is moving from, and where it's moving to. If it must move all the way across the disk, your wait is long; if it's moving to only the next track, your wait is short. "On the average", you wait for the head to move slightly more than a third as far as the distance from the disk's outermost track to the disk's innermost track.

Revolutions

After the head has reached the correct track, you must wait for the disk to revolve, until the correct part of the track reaches the head. How fast does the disk revolve? A 5-inch floppy disk revolves 5 times per second (which makes 300 rpm); an 8-inch floppy disk revolves 6 times per second (360 rpm); a hard disk revolves either 40 or 60 times per second (2400 or 3600 rpm), depending on how much you paid for the drive.

"On the average", you wait for the disk to make half a revolution. At 300 rpm, half a revolution takes 100 milliseconds; at 360 rpm, it takes $83\frac{1}{3}$ milliseconds; at 2400 rpm, it takes $12\frac{1}{2}$ milliseconds; at 3600 rpm, it takes only $8\frac{1}{3}$ milliseconds.

Density

"Density" means "bytes per track". Very often, a manufacturer will invent a disk drive, and then invent an "improved" drive, which squeezes twice as many bytes onto each track; the improved drive has twice the density of the first drive, and is therefore called a *double-density drive*. So *double-density* means "twice as many bytes per track".

Doubling the density helps you in two ways. First, it means you can store twice as much information on the disk. Second, it doubles the *transfer rate*—the rate at which information is transferred from the disk to the computer, after the head has already reached the correct track. The transfer rate depends on how fast the disk spins, and how many bytes are on each track. If you double the density, you're doubling the number of bytes per track, so you're reading twice as many bytes per revolution.

Sectors

Each track is a circle. To organize the information on the track, you must divide the track into *track-sectors (t-sectors)*; each t-sector is an arc of the circle.

Each t-sector contains many bytes. The t-sector's first few bytes contain the t-sector's *identification (ID)*. The rest of the t-sector is called the *physical record*; it contains your data. The number of bytes for the data is usually either 128 or 256 or 512. If it's only 128, the t-sector is small; if it's 512, the t-sector is large. You can subdivide the track into many short t-sectors or a few long t-sectors.

Formatting

When you buy a blank disk, you must *format* it. Formatting the disk consists of several steps....

You must decide how long the t-sectors will be: 128 data bytes, or 256, or 512.

You must write the t-sector ID's.

When you drive a car, you want to have a spare tire, in case you get a flat. Similarly, when you put a disk into a disk drive, you want to have a spare track, in case one of the other tracks gets scratched. When formatting the disk, you must decide whether any of the tracks will be "spares".

Later, when you put data onto the disk, you'll want to organize the data into *files*; each file will consist of several t-sectors, and will have a name. The most important file is the *directory*, which tells where to find all the other files. The directory is actually a table of information: for each file, it tells the file's name, track number, and t-sector number. To retrieve a specific file from the disk, you'll first go to the directory, which tells where to find the file; then you can go to the file you're interested in.

When you're formatting the disk, you must decide where to put the directory. Your best bet is to put it on a track that's halfway between the outermost track and the innermost track. For example, if your tracks are numbered from 1 to 35, put the directory on track 17. That way, the heads will never be very far from the directory, and so you can get to the directory quickly.

If your disk is large and your data is complicated, you might have to divide the directory into subdirectories, and your files into subfiles. So you might have to move the head several times to find the data you wish.

Your computer probably comes with a program called FORMAT, which does all those things for you automatically. It automatically decides how long to make the t-sectors, writes the t-sector's ID's, decides whether to create spare tracks, and establishes a directory on the halfway track.

When somebody tries to sell you a disk, he'll talk about the "unformatted capacity" and the "formatted capacity". The *unformatted capacity* is the total number of bytes on the disk. The *formatted capacity* is how many bytes are left for your data, after the disk has been formatted. The formatted capacity is less than the unformatted capacity, because of the space taken up by the t-sector ID's, the spare tracks, and the directory.

Floppy disks

This table compares four of the most popular floppy-disk drives:

#1. Drive's manufacturer	Shugart	Pertec	Micropolis	Shugart
#2. Drive's model-number	400	FD200	1043-II	800
#3. Disk's diameter	5 inches	5 inches	5 inches	8 inches
#4. Tracks	35 tracks	40 tracks	77 tracks	77 tracks
#5. T-sectors per track	10	10	16	26
#6. Data bytes per t-sector	256 bytes	256 bytes	256 bytes	128 bytes
#7. Data bytes per track (#7 = #5 times #6)	2,560 bytes	2,560 bytes	4,096 bytes	3,328 bytes
#8. Total data bytes (#8 = #4 times #7)	89,600 bytes	102,400 bytes	315,392 bytes	256,256 bytes
#9. Data bytes, excluding the directory & spare tracks (#9 = #8 minus dir&spares)	87,040 bytes	99,840 bytes	311,296 bytes	242,944 bytes
#10. Average head motion (#10 = time to move the head across $\frac{1}{3}$ of tracks + time to drop the head onto the disk)	463 msec	335 msec	780 msec	211 msec
#11. Revolutions per second	5 rps	5 rps	5 rps	6 rps
#12. $\frac{1}{2}$ revolution (#12 = 500 msec divided by #11)	100 msec	100 msec	100 msec	83 msec
#13. Average total access time (#13 = #10 + #12)	563 msec	435 msec	880 msec	294 msec
#14. Data bytes transferred per second, if you don't change tracks (#14 = #7 times #11)	12,800	12,800	20,480	19,968

Each of those drives has just one head, which moves across one side of the disk. To use the disk's other side, you must flip the disk over, by hand. Most programmers leave the flip side blank. In the table, I assume you're using just one side of the disk; the flip side is blank.

Of those four drives, the most famous are the ones by Shugart: the model 400 puts 35 tracks onto a 5-inch diameter; the model 800 puts 77 tracks onto an 8-inch diameter.

The drives by Pertec and Micropolis are improvements over Shugart's model 400. Onto a 5-inch diameter, Shugart squeezes only 35 tracks, whereas Pertec squeezes 40, and Micropolis squeezes 77. So Micropolis squeezes as many tracks onto 5 inches as Shugart puts on 8 inches.

Each of those drives uses 1 track for the directory. The Shugart 800 uses 3 tracks as spares; the other drives have no spare tracks at all.

Notice that the Micropolis drive holds the most data bytes (#9), and transfers the most data bytes per second (#14), but on the other hand has the slowest access time (#13).

Salesmen can mislead you. For example, how many bytes are on the Shugart 400? Would you say 89,600 bytes (#8), or 87,040 (#9), or 109,375 (which is the total number of bytes, including even the t-sector ID's)? How fast is the Shugart 400? Would you say 463 msec (#10), or 563 (#13), or 50 (which is how long the head takes to move from a track to the *adjacent* track, and drop)?

When the head has finally reached the data you're interested in, how fast will the drive transfer the data to you? Will it be at 12,800 bytes per second (#14), or more, or less?

Frankly, I wouldn't worry about it. But when two salesmen are arguing with each other about which disk drive "holds the most" and "is the fastest", make sure both salesmen are doing their calculations by the same method.

Some salesmen purposely fudge the figures: they use an "optimistic" method of calculating the abilities of their own disk drives, and a "pessimistic" method of calculating the abilities of their competitors. For example, Micropolis claims its disk drive holds "more than four times as much" as the Shugart 400; Micropolis exaggerates. Similarly, Percom claims the Pertec FD200 holds 28% more than the Shugart 400; Percom exaggerates. If the Federal Trade Commission were to find out about those exaggerations, those companies would be in hot water.

For the Shugart 400, Radio Shack charges $499. Radio Shack calls it the "TRS-80 Minidisk Drive". It attaches to Radio Shack's TRS-80 computer.

Instead of buying the regular Shugart 400, you can buy a double-density version, which holds twice as much data, and which North Star sell for $799, to attach to North Star's Horizon computer.

For the Pertec FD200, Percom charges only $399. Percom calls it the "TFD-100", and tells how to attach it to the TRS-80 computer.

Exidy charges $2995 for a combination that includes *two* Micropolis 1034-II drives plus a display terminal. You can attach it to Exidy's Sorcerer computer.

Percom sells the Micropolis 1034-II for just $675. Percom calls it the "TFD-200", and tells how to attach it to the TRS-80 computer. But the TRS-80 will use only 10 of the 16 sectors; the other 6 sectors will remain blank. And to attach the drive to the TRS-80 reliably, you must also buy Percom's "Separator", which costs $30.

Many computer stores sell the Shugart 800 (or a similar 8-inch drive from another manufacturer); prices vary. You can buy a double-density version, which stores twice as much.

Although a floppy-disk *drive* costs several hundred dollars, the floppy disk itself costs less than $10. In fact, a blank 5-inch floppy disk costs about $3.50, and a blank 8-inch floppy disk costs about $6.50.

If you're almost broke, buy just one floppy-disk drive, and pop many disks in and out of it— one disk at a time. If you have more money, buy a second drive. Two drives are much better than one: with two drives, you can put a programmed disk into one drive, put a blank disk into the other, and then tell the drives to copy the information from the first disk to the second. If you have only one drive, copying a disk is much harder.

History. The first floppy disk was invented long ago, by IBM, and was 8 inches. The first 5-inch floppy disk was invented in 1976, by Shugart, for the model 400 drive. The first controller for Shugart's 5-inch floppy-disk drive was invented in 1976, by North Star.

Hard disks

The "standard" disk drive is IBM's model 3330. The typical 3330 holds 1 disk pack (though you can buy a version that holds 2 disk packs). The pack is called the 3336; it contains eleven 14-inch disks. Since each disk has two surfaces, that makes 22 surfaces. Only 19 of the surfaces are used; the other 3 surfaces are blank.

Each track contains 13,020 bytes. If you buy the model 3336-I, each surface contains 404 tracks (plus 7 spare tracks, which I won't count); so the entire pack contains 13,020 bytes times 404 times 19, which is 100,018,280 bytes. If you buy the model 3336-II instead, each surface contains 808 tracks (instead of 404); so the entire pack contains 200,036,560 bytes. Rounding those figures, the model 3336-I contains 100 M; the model 3336-II contains 200 M. Those figures are the *unformatted* capacities; the formatted capacities are slightly less.

The disks revolve 60 times per second (3600 rpm). The average head motion is 30 msec; a half-revolution is about 8 msec; so the total average access time is 38 msec. The transfer rate is 806 K/sec.

Discount houses charge about $450 for the 3336-I disk pack, and $625 for the 3336-II. Those prices include the disks but not the drives, which cost many thousands of dollars.

DEC sells an imitation of IBM's disk drives, for use in DEC's PDP computers. DEC's RP04 disk drive holds a 3336-I disk pack; DEC's RP06 disk drive holds a 3336-II disk pack; the drives go at exactly the same speed as IBM's. The RP04 costs $36,750; the RP06 costs $44,000; those prices include the drive, the disk pack, and the controller. The controller can handle 7 extra drives; each extra drive costs $27,200 (RP04) or $34,000 (RP06).

IBM, DEC, and other companies (especially CDC) sell many other models also. Some models are smaller and cheaper; others are larger; others are faster.

IBM's newest and largest disk drive is the 3370. It holds 571 M, and transfers 1.9 M/sec. The price is surprisingly low: the first drive costs $35,100; each additional drive costs $23,400. IBM's price for the first drive does *not* include the controller,which costs extra. A controller that can handle 32 drives, and that attaches to IBM's 4341 computer, costs $62,350. If you put on 32 drives, your total capacity is "32 times 571 M", which is 18.2 *billion* bytes (18.2 gigabytes, 18.2 G); your total cost is "$62,350 (for the controller) + $35,100 (for the first drive) + 31×$23,400 (for the 31 additional drives)", which is $822,850. So you're paying $822,850 for 18.2 G. That comes to about $45,000 per G, or $45 per M, or 4½¢ per K.

The cheapest decent hard-disk drive is the one manufactured by International Memories Incorporated (IMI) and sold by Corvus. It holds a pair of 8-inch hard Winchester disks. Altogether, the pair of disks hold 11 M unformatted (about 9½ M formatted). The average head motion is 45 msec. The disks revolve at 3600 rpm, so a half-revolution takes 8 msec; the total average access time is therefore 53 msec. The total price (for the drive, the pair of disks, and the controller) is $5350. Unfortunately, the disks can*not* be removed from the drive; the drive is airtight, to prevent dust. You can increase the capacity by buying additional drives; each additional drive costs just $2990 (that price includes the drive and its pair of disks; the drive uses the first drive's controller). The controller can handle four drives. Corvus builds controllers for several kinds of computers: Radio Shack's TRS-80 model 1, TRS-80 model 2, the Apple 2-plus, the Altos, the computers that have an S-100 bus, and computers that have an LSI-11.

Like Corvus, Lobo sells the IMI drive and a controller that attaches it to the TRS-80 model 1 and the Apple 2-plus. Lobo's prices are similar to Corvus's. We have some evidence that Corvus's controller and programs work better than Lobo's.

Corvus and Lobo prove that you can attach an 11M drive to a microcomputer. Other companies sell even *larger* drives for microcomputers. North Star makes the Horizon microcomputer, and lets you attach it to an 18M drive. Ohio Scientific makes the Challenger 3 microcomputer, and lets you attach it to a 23M drive and a 74M drive.

SUMMARY

These charts summarize the various kinds of memory:

What to buy

	Tapes	Disks	RAM
cheap microcomputer	audio cassette	none	MOS
cheap mini (or fancy micro)	digital cass. or cartridge or none	floppy or hard	MOS
fancy mini (or cheap maxi)	reel-to-reel	hard	MOS
fancy maxicomputer	reel-to-reel	hard	MOS&bipolar

Average access time per byte

(the amount of time, on the average, to skip to a random byte and read it)

	Tapes	Disks	RAM
1,000 sec			
100 sec	audio cassette & reel-to-reel		
10 sec	digital cassette & cartridge		
1 sec			
100 msec		floppy	
10 msec		hard	
1 msec			
100 μsec			
10 μsec			
1 μsec			
100 nsec			MOS
10 nsec			bipolar

Transfer rate

(how fast the info is transferred from memory to computer, if you don't have to skip)

	Tapes	Disks	RAM
10 bytes/sec			
100 bytes/sec	audio cassette		
1 K/sec			
10 K/sec	digital cassette & cartridge		
100 K/sec		floppy	
1 M/sec	reel-to-reel	hard	
10 M/sec			MOS
100 M/sec			bipolar

Number of bytes in one drive (or one unit)

	Tapes	Disks	RAM
1 K			bipolar
10 K			
100 K	audio cassette & digital cassette	floppy disk	MOS for microcomputer
1 M	cartridge		MOS for minicomputer
10 M	reel-to-reel for minicomputer	hard disk for minicomputer	MOS for maxicomputer
100 M	reel-to-reel for maxicomputer	hard disk for maxicomputer	
1 G			

Cost of one drive (or one unit)

	Tapes	Disks	RAM
$10	audio cassette		bipolar & MOS (micro)
$100	digital cassette	floppy	MOS (micro) & bipolar
$1,000	reel-to-reel (mini) & cartridge	hard (micro)	MOS (mini)
$10,000	reel-to-reel (maxi)	hard (mini or maxi)	MOS (maxi)
$100,000			

Cost per kilobyte

	Tapes	Disks	RAM
.01¢	cartridge & reel-to-reel (medium)		
.1¢	audio cassette (medium)	hard (medium)	
1¢	digital cassette (medium)	floppy (medium)	
10¢	audio cass. & cartridge & reel-to-reel (drive)	hard (drive)	
$1	digital cassette (drive)	floppy (drive)	
$10			MOS
$100			bipolar
$1,000			

CPU

UNDERSTANDING ENGLISH

The CPU (the central processing unit) is the computer's "brain". But it's not very smart. It doesn't understand any English. It does *not* understands words such as PRINT or RUN or LOG or HELLO or BASIC. It understands only a primitive language, called *machine language*, which consists of just zeros and ones.

To make the computer understand some English, you must store in the computer's memory a dictionary of English words; the definitions must be written in machine language (since that's the only language the CPU understands). You must also store an explanation of some English grammar; again, the explanation must be written in machine language.

Where in the memory do you put those explanations of English? If you're manufacturing a computer, you have two choices: you can put the explanations into ROM (so they're in the main memory permanently), or you can put them onto a disk and then copy them from the disk into RAM. Which method is better?

If you're completely sure of what you're doing, put the explanations into ROM. But if you think that you might want to make improvements or changes later, put the explanations onto a disk instead, because changing what's on a disk is easier than changing what's in a ROM.

HOW SMART IS THE COMPUTER?

To decide how "smart" a computer is, don't just look at the CPU. You must also look at the ROM and disk, to see how much information the manufacturer put there. The CPU, the ROM, and the disk are the three ingredients that determine how "smart" the computer is.

WHAT DOES THE CPU LOOK LIKE?

In most microcomputers, the CPU is just a single chip. It looks like a ROM chip. It's hidden in a DIP ("caterpillar"), which is mounted on a PC board. It costs about $10. Although it's the computer's "brain", it's the least important part of the computer: the ROM, the disks, and the rest of the computer (such as the RAM and I/O devices) are much more important, and are what makes the computer cost so much.

A CPU that consists of a single chip is called a *microprocessor (μP)* or *microprocessor unit (MPU)*. In larger computers, the CPU consists of *many* chips, which are wired together.

Remember: a computer's "personality" depends mainly on the ROM and disk; the CPU is relatively unimportant. In fact, if you peek inside two microcomputers made by different companies, you'll probably find that their CPU's are *the same*!

FAMOUS MICROPROCESSORS

The most popular microprocessor is the Z-80, invented by Zilog (which has become a subsidiary of Exxon). The Z-80 is used in these computers: Radio Shack's TRS-80 model 1, Radio Shack's TRS-80 model 2, Exidy's Sorcerer, North Star's Horizon, Intertube's Superbrain, Cromemco's Z-2H, and Heath's WH89.

The other popular microprocessor is the 6502, invented by MOS Technology (which has become a subsidiary of Commodore). The 6502 is used in these computers: Commodore's PET, Commodore's CBM, MOS Technology's KIM, Apple's Apple 2, Apple's Apple 2-plus, Atari's 400, Atari's 800, and Ohio Scientific's Challenger.

An older microprocessor, Intel's 8080, is used in the Compucolor 2 and the Heath H8. A newer microprocessor, Motorola's 6809, will probably be used in the forthcoming Apple 3 and TRS-90. Texas Instruments' 9900 microprocessor is in some Texas Instruments computers (such as the TI-99/4 and the TI-990/4).

Popular microcomputers

RADIO SHACK

Radio Shack's TRS-80 Model 1 computer is the most popular microcomputer ever manufactured by anyone. Though Radio Shack won't release exact figures, most industry analysts estimate that Radio Shack's sold 200,000 TRS-80 Model 1 computers, and that the figure of 200,000 is much more than *all* other manufacturers combined.

Radio Shack also makes a TRS-80 Model 2. But because it costs so much more than the Model 1, it isn't as popular.

Both models of the TRS-80 contain a Z-80 CPU and use a black-and-white video.

Model 1

The base price for the model 1 is $499. It includes the main cabinet, a 12" black-and-white monitor (made by RCA), a cassette tape recorder, and various aids: an AC/DC power transformer, an easy-to-read cheery instruction book, and a tape that contains programs for blackjack and backgammon.

The main cabinet includes a Z-80 CPU, a built-in keyboard, a 4K ROM (that contains Level-1 BASIC), a 4K "user" RAM (for your programs), a 1K RAM for the keyboard, and a 1K RAM for the video.

The main cabinet is painted gray. Why did Radio Shack pick such a blah color? Answer: according to Radio Shack, it's not "gray"; it's "Mercedes silver". When you look at Radio Shack's computer, you're supposed to imagine yourself driving a Mercedes.

Many ugly wires run from the main cabinet out to the tape recorder, monitor, and power transformer. Why didn't Radio Shack hide the transformer *inside* the main cabinet, to reduce the number of wires? Answer: Radio Shack wanted its computer system to be declared "safe from electrical fire and shock" by Underwriters Laboratories (UL), because many schools and government agencies refuse to buy electrical equipment that isn't "UL-approved"; but UL approves equipment slowly; if Radio Shack had put the transformer *inside* the main cabinet, UL would have needed an additional six months to check it out; Radio Shack didn't want to wait that long.

To improve Radio Shack's computer, your first step is to replace the 4K ROM (which contains Level-1 BASIC) by a 12K ROM (which contains Level-2 BASIC). Level-2 BASIC is excellent; Level-1 BASIC is incomplete. For example, Level-1 BASIC permits only two string variables (which must be called A$ and B$, and which cannot be compared against each other); it permits only one numeric array (which must be called A); string arrays are not allowed.

Why is Level-1 BASIC so bad? Answer: Radio Shack hired outside consultants to write Level-1 BASIC; halfway through the job, the consultants had an argument with Radio Shack, and quit! So Level-1 BASIC was never finished. That's why it lacks so many features. For Level-2 BASIC, Radio Shack hired a different consulting firm, Microsoft, which has an excellent reputation, and which did a nice job.

So you'll want to switch from Level-1 BASIC to Level-2 BASIC. The switch costs $120. That's how much Radio Shack charges, to remove the 4K ROM and replace it by the 12K ROM. Your total cost: $499 (for the base price) + $120 (for the switch) = $619.

Unfortunately, the manual for Level-2 BASIC is not as easy to read as the manual for Level-1 BASIC. That's because David Lien, who wrote the excellent Level-1 manual, quit. He's started his own publishing company, called Compusoft. His easy-to-read Level-2 manual, published by Compusoft, costs $15.95; it's called *Learning Level 2*. Radio Shack does *not* sell it; so to buy it, you must either go to an independent computer store or write directly to Compusoft (which charges $1.45 for postage and handling).

Note the irony: Radio Shack sells Level-1 BASIC (a lousy version of BASIC that comes with an excellent manual) and Level-2 BASIC (an excellent version of BASIC that comes with a lousy manual).

Radio Shack recommends that you buy Level-1 BASIC first (because of its excellent manual), and later switch to Level-2 (when you become brave). But beware: most of the programs in *The Secret Guide to Computers*, and in most other books, will *not* work with Level-1 BASIC; you need Level-2. So you might be better off plunging into Level-2 BASIC, using *The Secret Guide to Computers* together with *Learning Level 2*.

Level-2 BASIC uses some different notations than Level-1 BASIC. So if you write a program for Level-1 BASIC, and then switch to Level-2, you must rewrite the program. What a mess!

After you've finally bought your Level-2 machine (for a total cost of $619), your next step is to buy more RAM, so that the computer can hold longer programs. For $230, Radio Shack will remove the 4K user RAM and replace it by a 16K user RAM. Also, Radio Shack will install a "numeric keypad" on your keyboard, to let you input numbers more easily. Your total cost: $619 (for the computer containing Level-2 and 4K user RAM) + $230 (for switching to 16K user RAM and installing the numeric keypad) = $849. The result: you have a pleasant computer that can run many programs easily. This $849 version is the one found in most schools and homes. In fact, the average customer who walks into a Radio Shack store to buy a computer plunks down $849 all at once, and walks out with a nice computer.

If you wish to expand further, your next step is to buy a box called the *expansion interface*. It costs $299. The box is mostly empty, but lots of wires come out of it; you can attach those wires to disks, printers, tape recorders, acoustic couplers, and other options. Inside the box, there's enough room to put additional RAM, an RS-232 interface (to connect to an acoustic coupler), and other circuitry; but those items are *not* included in the basic $299 price. The only things the price includes are a clock, a second AC/DC transformer, and three controllers: one controller handles a printer; another controller handles a second tape recorder; and the third controller handles four disk drives. The price includes the controllers, but does *not* include the printer or tape recorder or disk drives. By itself, the box is useless; but you must buy it before you buy additional RAM, and acoustic coupler, disks, a printer, or an additional tape recorder; it's a prerequisite. Your total cost so far: $849 (for the computer containing Level-2 and 16K user RAM) + $299 (for the expansion interface) = $1148.

Your next step is to buy a disk drive, and attach it to the expansion interface. Radio Shack's drive is made by Shugart; it's Shugart's model 400, which uses a 5-inch floppy 35-track disk. For $499, Radio Shack will sell you that drive, plus a cable (which connects the drive to the expansion interface, and which has enough room on it to hold three more drives), plus a disk that contains the *disk operating system (DOS, pronounced "doss")*, which is a series of programs you need in order to use the drive. So your total cost is $1148 (for the computer and expansion interface) + $499 (for the drive and cable and disk) = $1647.

When you buy that disk drive, you'll be very happy, because it's so much easier to use than the tape recorder. The tape recorder is slow and unreliable (it makes many errors); the disk system is excellent.

But the disk system has one drawback: the computer copies 10K of the DOS from the disk to the RAM; so of the 16K user RAM you bought, 10K are used by the DOS, and only 6K remain for your own programs.

Therefore, your next step is to buy more RAM and put it into the expansion interface. For $149, Radio Shack will put 16K user RAM into your expansion interface; so altogether, you'll have 16K user RAM in the main cabinet, plus 16K RAM in the expansion interface, giving you a grand total of 32K user RAM— of which 10K is used by the operating system. Your total cost so far: $1647 (previously) + $149 (for the additional 16K RAM) = $1796.

Your next purchase— if you can afford it— is a second disk drive. It costs an additional $499. It offers you many conveniences. For example, you can more easily make a copy of a disk: just put the disk you want to copy in one drive, put a blank disk in the other drive, and tell the computer to copy from one to the other. If you have only one drive, the procedure is more tedious: you must pop the two disks in and out of the same drive, and transfer the information a piece at a time, from one disk to the RAM to the other disk; it's a pain! You'll be much happier with two drives. Your total cost so far: $1796 (previously) + $499 (for the second disk drive) = $2295.

That's all I recommend. If you want to splurge, you can buy two extra disk drives (at $499 each) or a third bank of 16K RAM (at $149); but for most applications, such purchases are unnecessary.

Model 2

The Model 2's main cabinet is unusual: it includes a Z-80 CPU, a 32K RAM, a small ROM (about 1K), a keyboard, a 12" black-and-white CRT, a disk controller, and an 8" floppy disk drive. Notice these contrasts:

	Model 1	Model 2
ROM	4K or 12K; contains BASIC	about 1K; contains part of the operating system
disk's size	5" floppy	8" floppy, double-density
disk drive's location	outside the main cabinet	built into the main cabinet
disk's contents	2½K directory, 33½K BASIC & DOS, 50K for yourself	6½K directory, 63½K BASIC & operating system, 416K yourself
text on screen	64 characters per line; 16 lines on the screen	80 characters per line; 24 lines on the screen
Can the screen show lower-case letters?	costs $99 extra	yes
Can you draw artistic pictures on the screen easily?	yes	no

As you can see from the last comparison, the Model 2 is *worse* than the Model 1, if your goal is to draw pretty pictures. But for applications to business, the Model 2 is better.

Unfortunately, the Model 2 costs much more than the Model 1. The base price for the Model 2 is $3450. That includes the main cabinet (with CRT, disk drive, etc.), a disk that contains BASIC and the operating system, and a manual. The manual is easier to read than the Model 1 Level 2 manual, but not as easy as the Model 1 Level 1 manual.

Unfortunately, when you turn the computer on, it begins by copying 27K of the "BASIC and operating system" from the disk to the RAM. So of the 32K RAM you bought, only 5K remains for your own program. To improve the Model 2, your first step is to buy additional RAM. Radio Shack will sell you 32K additional RAM for $449. So altogether, you'll have 64K RAM, of which 27K is used by BASIC and the operating system. Your total cost: $3450 (base price) + $449 (for 32K additional RAM) = $3899.

Radio Shack expects the average customer to stop there, and spend just $3899. But if you wish to go further, buy the "1-drive expansion system", which is a box that includes an extra disk drive. It costs $1150. Your total cost so far: $3899 + $1150 = $5049.

That 1-drive expansion system includes extra slots, into which you can insert extra disk drives. The extra drives cost $600 apiece. So if you want four disk drives altogether (one in the main unit, one in the 1-drive expansion system, and 2 in the empty slots), your total cost is $5049 + $600 (for the third drive) + $600 (for the fourth drive) = $6249.

If you still have extra money in your pocket, and would like to spend more than $6249 on basics, tough luck! Radio Shack doesn't go any higher yet. Instead, spend those dollars on printers, furniture, and programs.

Printers

Radio Shack offers many printers (most of which are made by Centronics):

Name	Paper	Fully-formed Characters?	Characters per line	Price of printer	Price of cable	Speed
Quick Printer 2	aluminized	no	32	$219	$00,$20,$xx	120 lpm
Quick Printer 1	aluminized	no	80	$499	$59,$39,$39	150 lpm
Line Printer 2	regular	no	80	$970	$59,$29,$29	100 cps
Line Printer 1	regular	no	132	$1559	$59,$39,$39	100 cps
Line Printer 3	regular	no	132	$1960	$xx,$39,$39	120 cps
Daisy Wheel Printer	regular	yes	132	$2999	$xx,$00,$xx	45 cps

In that table, "lpm" means "lines per minute"; "cps" means "characters per second".

"Aluminized" paper costs more than "regular paper"; on the other hand, if you buy aluminized paper, you don't have to buy any ribbons. The printers that use aluminized paper are cheaper and go faster than the ones that use regular paper.

The price of the cable depends on which computer you want to attach the cable to. So the table lists three prices: use the first price if you have a Model 1 without an expansion interface; use the second price if you have a Model 1 *with* an expansion interface; use the third price if you have a Model 2. "$00" means the cable is free; "$xx" means the cable is not available.

Furniture

Radio Shack will sell you furniture, to rest your equipment on.

What the furniture is called	How much you can put on it	Price
Space-Saver Stand	Model 1 main cabinet & tape recorder & expansion interface & monitor & 2 disk drives & Quick Printer	$50
Model 1 System Desk	all the above, plus 2 extra disk drives	$199 + $29 (for a fan)
Model 2 System Desk	Model 2 main cabinet & 3 extra disk drives & any printer	$350
Line Printer Stand	Line Printer 1 or Line Printer 2	$99
Line Printer 3 Stand	Line Printer 3	$139

If you don't want to buy that furniture, you can use any old desk or table that's lying around your home, school, or office. But Radio Shack's furniture has several advantages: it's exactly the right size; it matches your computer's colors; and it contains secret compartments that hide the ugly wires.

Programs

Radio Shack's most popular business programs are these:

Program	Model 1 16K user RAM no disk drives	Model 1 32K user RAM two 5" disk drives	Model 2 64K user RAM one 8" disk drive
mailing list	$20 (80 names)	$100 (990 names)	$79 (4000 names)
word processing	$70 (slow)	$100 (fast)	not available
general ledger	not available	$100 (100 accounts)	$199 (500 accounts)
inventory	not available	$100 (1000 items)	$199 (3000 items)
accounts receivable	not available	$150 (300 accounts)	$299 (2000 accounts)
accounts payable	not available	$150 (200 vendors)	$299 (2000 vendors)
payroll	$50 (15 employees)	$200 (99 employees)	$399 (500 employees)

Radio Shack also sells programs for business accounting, real estate, statistics, stocks, the construction industry, games, music, art, tutoring, classroom management, balancing your personal checkbook (and budget), and advanced programming. Most of those programs are for the Model 1. The Model 2 is newer, and not many programs have been written for it yet. So if you want to use the computer for a wide variety of applications, and don't want to write the programs yourself, get the Model 1 (*not* the Model 2).

Repairs

If Radio Shack equipment ever breaks, the fastest way to fix it is to take it to one of Radio Shack's regional repair centers. Usually, the repair will be done within 24 hours.

If you don't feel like driving to the regional repair center, just bring the equipment to your local Radio Shack store. (Radio Shack has 7,500 stores!) The store will ship the equipment to the repair center, which will fix it and ship it back to the store. You're *not* charged for the shipping. The turnaround time (including the repair and the shipping) is 3 days, if you're luckly. A week is more typical. The exact timing depends on whether you just missed Radio Shack's van, which travels from store to store and delivers the equipment. When using this method, make sure you write on paper, as clearly as possible, an exact description of what needs repair; and tape that paper to the equipment. Otherwise, the store manager will send a vague description to the repair center, which will do a different kind of repair than what you intended.

All Radio Shack equipment comes with a 90-day warranty. So if the repair occurs during the first 90 days, you aren't charged for it. After 90 days, you're charged for parts and labor. Radio Shack charges very little for parts, and usually charges $30/hour for labor. The repairman rarely takes longers than an hour; so your total labor charge will probably be $30.

When the repair center fixes your computer, it sends the bill to the store at which you placed the repair request. If your computer isn't under warranty, the store passes the bill to you; but if the computer is still under warranty, the store's manager must pay the bill himself.

Suppose you buy a computer in New York, move to California, the computer breaks down, and you take it to a Radio Shack store in California and demand repairs while the computer is still under warranty. The store manager in California will try to convince you to ship the computer back to New York— because he doesn't want to pay the repair bill. But legally, if you insist that he take care of the repair (and if you show him your original sales slip, to prove that the computer is still under warranty), he has no choice: he must honor your request for free repair. To cheer him up, remind him that he, in turn, has the right to mail the repair bill to the store in New York— if he spends a few minutes to do the paperwork that Radio Shack requires.

Most Radio Shack equipment is sealed. The repairman breaks the seal, opens the equipment, fixes it, and puts on a new seal. If *you* break the seal (accidentally, or by tinkering with the inside of the computer), you void the warranty, the labor charge is $60/hour, and the repairman will undo your tinkering— even if your tinkering was an improvement.

Although the warranty period is normally 90 days, you can extend it. For an additional *year* of warranty, Radio Shack charges 15% of the equipment's list price. That's what you might call a "one-year service contract"; but notice that to get repairs, you must still bring the equipment to Radio Shack; no Radio Shack repairman will visit your home or office.

After the first 90 days, Radio Shack computers rarely need additional repairs; so you probably should *not* buy the service contract; it's a waste of money. The contract is intended only for government agencies (such as schools) that *require* a contract. On the other hand, if you're using the computer *very often*, and if your computer system contains many mechanical devices (such as printers and disk drives), you might need frequent repairs, and so the contract might prove worthwhile.

You can get the contract from Radio Shack's Service Contract Administrator, Mr. J.D. Hartman. If you live in Texas, call him at (817) 390-3801; if you live elsewhere, call him at (800) 433-5502, toll-free. Or write to him at P.O. Box 17520, Fort Worth, TX 76102. To avoid surcharges, apply for the contract before *60* days of your regular warranty period have expired.

Questions

If you've bought a Radio Shack computer, and you're having difficulty getting it to work, call Radio Shack's hot-line. If you live in Texas, call (800) 772-5914, toll-free; if you live elsewhere, call (800) 433-1679, toll-free. The phones might be busy; keep trying. If you get tired of trying, call the other number: (817) 390-3583 (not free).

Or, if you prefer, write a letter to Radio Shack Computer Services, 900 Two Tandy Center, Fort Worth, TX 76102. In the letter, include a phone number where you can be reached during business hours; Radio Shack will reply by phone.

Radio Shack will *not* write or debug your programs. But it *will* answer all your other questions (technical or elementary) about Radio Shack computers: how to turn the computers on, get them to work, and use them.

Kinds of stores

The typical Radio Shack store sells all sorts of electronic equipment: computers, stereos, radios, etc. The store earns most of its money by selling stereos and radios: few people who walk into a store intend to buy a computer. So the salesmen concentrate on stereos and radios, and know very little about computers. You'll see very little computer equipment on display; and the store has very little computer equipment in stock. Shopping for a computer there is *not* pleasant! Nevertheless, if you already know what you want (and don't need a salesman's explanation), and you're not in a rush, you can place an order for whatever you want; the store will get it from headquarters, and give it to you a few days later— if you're lucky. Some items take weeks or months. Before you order, ask how long the delay is.

Of Radio Shack's 6,000 stores, a hundred are in better shape: they have a *computer department*, with many computers on display, and with salesmen who *do* know a lot about computers.

Radio Shack also has fifty *computer centers*. These centers sell *only* computers (no stereos, no radios). They have the most sophisticated computer salesmen, and the widest variety of computer equipment on display and in stock. Most centers also have a repair room (where broken computers are fixed) and a classroom (where courses are given on how to use Radio Shack's computers).

All those places— the ordinary stores, the stores-with-computer-departments, and the computer centers— are owned by Radio Shack. They are *company-owned*. They all charge the same prices. They don't offer discounts. (If a manager offers you a discount or a "special deal", he gets fired.) All the computer equipment they sell has Radio Shack's name on it. (You can't buy an Apple computer or a PET computer there. You can't buy a program written by someone independent of Radio Shack. You can't buy magazines or books that mention Radio Shack's competitors.) If you try to learn about computers just by browsing through those places, you'll get a very narrow view.

For a more interesting experience, talk with a Radio Shack *dealer* instead. A dealer is a person (or company) that buys lots of computers from Radio Shack, at a discount, and resells them. Since the dealer is *not* owned by Radio Shack, the dealer is free to sell competing products also. And the typical dealer will sell you Radio Shack equipment *below* list price.

The table on the next page shows the four most famous dealers. Three of them are *authorized dealers*, which means they can give you Radio Shack's warranty; the fourth dealer (VR Data) is *unauthorized*, which means it must give its own warranty instead. (On the other hand, VR Data offers the lowest repair rates, and offers the greatest variety of *non*-Radio-Shack items that plug into your Radio Shack computer.)

	Micro Management Systems	Pan American Electronics	C&S Electronics Mart	VR Data
Address	Radio Shack Dealer/Comp. Ctr. Downtown Plaza Shopping Ctr. 115C 2nd Avenue SW Cairo, GA 31728	1117 Conway Mission, TX 78572	32 East Main Milan, MI 48160	777 Henderson Blvd. N-6 Folcroft, PA 19032
Phone	(912) 377-7120	(512) 581-2765	(313) 439-1508	(215) 461-5300
Toll-free phone, for out-of-state orders	none	(800) 531-7466	none	(800) 345-8102
Discount on Radio Shack items, if you pay by credit card	12% for Model 1 items 7% for Model 2 items	10%	10%	4%
Discount on Radio Shack items, if you pay by check or money order	15% for Model 1 items 10% for Model 2 items	12% for Model 1 items 10% for Model 2 items	10%	7%
Shipping	costs extra	free	free	costs extra
Tax on out-of-state shipments	none	none	none	none
Purchases under $100	no discounts	you must pay shipping	same as larger ones	no discounts
If the Radio Shack equipment breaks during the first 90 days, where can you get it repaired for free?	there, or at any store owned by Radio Shack	there, or at any store owned by Radio Shack	there, or at any store owned by Radio Shack	there only
Does the store also sell items (from other manufacturers) that plug into Radio Shack's computer, and cost you even less than Radio Shack's own version?	yes	yes	yes	yes

APPLE

Radio Shack is the most popular microcomputer company, mainly because Radio Shack's TRS-80 Model 1 costs so little, and because Radio Shack owns so many stores. Apple ranks second in popularity— because the Apple costs slightly more, and is sold only through independent dealers. But many people feel that the Apple is indeed worth the extra cost, and is a better deal than the TRS-80. The Apple is more reliable. The Apple comes with manuals that are written better. Apple's disk system is easier to use. The Apple can draw higher-quality pictures, and can also handle 16 colors. (The TRS-80 draws just black-and-white.) The Apple is sold through computer stores, where the salesmen know a lot about computers and can give you lots of help. (The TRS-80 is sold mainly through ordinary Radio Shack stores, where the salesmen know lots about radios and stereos but little about computers.) If your Apple ever needs repairs (which are extremely rare), your local Apple dealer will usually be able to fix the Apple immediately, by himself. (A Radio Shack store must ship the computer to a repair center.) The Apple has been selected by the state of Minnesota, as *the* computer for teaching kids; many schools in Minnesota have been writing programs for the Apple. (No organized movement exists for the TRS-80.) The Apple includes a built-in speaker, which makes "clicks", and which you can program to produce nice music. (Producing nice music on the TRS-80 is much harder.) The Apple includes game paddles, which you pull back and forth during games that involve motion. If you type a program that contains an error, the Apple prints a complaint that's written in easy-to-understand English. (The TRS-80 prints a two-letter code instead, unless you have a disk.) The newest Apple includes a "full-screen editor", which lets you revise your programs quickly and easily. (Revising a TRS-80 program is more awkward.) You can connect the Apple to the Dow-Jones stock-reporting service, for up-to-the-minute quotations. The Apple is more portable: the AC/DC transformer and slots for "expansion interface" are hidden in the main cabinet. (For the TRS-80, the AC/DC transformer and expansion interface are *outside* the main cabinet and connected by ugly wires; to transport the TRS-80, you must unplug the wires and carry all the separate pieces in your hands.) The Apple is prettier. (It's yellow instead of gray.) The Apple has a standard computer keyboard (Radio Shack's is weirder); so you can more easily connect the Apple to maxicomputers.

The original Apple, the Apple 1, was invented by two guys in a garage. Then they started Apple Computer Company. Later, they invented the Apple 2. Today, the most popular Apple computer is the Apple 2-plus....which is the version I'll discuss.

Main cabinet

The main cabinet includes a 6502 CPU, a built-in keyboard, a 14K ROM (containing Applesoft BASIC and the operating system), a "system" RAM (which helps the operating system), and 16K of "user" RAM (for your programs). For $1195, you get that main cabinet, plus 2 paddles, 2 books, and tapes containing sample programs.

You'll also need a cassette tape recorder and a video. Apple doesn't sell the tape recorder; so buy the tape recorder elsewhere. For the video, buy either a television set (with an RF modulator) or a television monitor.

Apple charges $150 for an additional 16K RAM. So if you want a total of 48K RAM, your total Apple cost is $1195 (for the main system, including 16K of user RAM) + $150 (for a second 16K RAM) + $150 (for a third 16K RAM) = $1495. Remember: that price does *not* include the tape recorder or the video.

Disks

For $595, you get a disk drive, a disk controller, a disk that contains the DOS, a blank disk (for your programs), and an easy, cheery manual.

Each disk is a 5-inch 35-track floppy. Apple squeezes more data onto a disk than Radio Shack: Apple squeezes 13 t-sectors onto each track; Radio Shack squeezes only 10. So Apple's disk holds 30% more data than Radio Shack's.

The computer copies about 10K of the DOS from the disk to the RAM; so if your Apple has just 16K of user RAM, about 10K are used by the DOS, and about 6K remain for your own programs. 6K isn't much; so most Apple programmers buy extra RAM.

The disk controller is a PC board that you put into the main cabinet. It can handle two disk drives. The second disk drive costs $495.

So altogether, if you want a "perfect" system, your total cost is:

$1195 for the main system, including 16K of user RAM
$150 for a second 16K RAM
$150 for a third 16K RAM
$595 for a disk system, including one controller and one drive
+$495 for a second drive
$2585 total, to which you must still add a video

Interface cards

To attach the Apple to another device, you must buy an *interface card*, and put it inside the main cabinet. The card is attached to a cable; the price of the card includes the cable. Four interface cards are popular:

The *Centronics interface card* costs $225. You can plug its cable into any printer manufactured by Centronics.

The *serial interface card* costs $195. You can plug its cable into any printer that uses an RS-232C interface.

The *standard parallel interface card* costs $180. You use it for printers (such as Axiom's and Integral Data's) that don't work with the previous two cards. To use it, you must also buy a *printer connector*, which connects the cable to the printer.

The *communications interface card* costs $225. You can plug its cable into an acoustic coupler (for using a telephone), or directly into a minicomputer or maxicomputer, or into any device (such as a printer) that uses an RS-232 interface slowly (10 or 30 characters per second).

Dealers

The Apple prices I've been giving you are the "suggested retail list prices". Some dealers will charge you less.

For example, the suggested retail list price of a "16K Apple 2-plus" (i.e., the main system, including 16K of user RAM) is $1195; but these dealers charge less:

$956 at Raygam, 6791 Westminster Ave., Westminster, CA 92683, (714) 891-2587, out-of-state (800) 854-6455 toll-free. To buy from Raygam, you must first join Raygam's "club"; membership is free. Raygam's $956 price is 20% less than the suggested retail list price. Raygam gives 20% discount on most items from Apple, Commodore, Atari, Texas Instruments, Exidy, Cromemco, Alpha Micro, Shugart, Hazeltine, Lear Siegler, Soroc, and other manufacturers. Raygam is closely related to a store called Computer World, which is at the same address but has a different phone: (714) 891-2584.

$995 at Olensky Brothers, Computer Sales Division, 3763 Airport Blvd., Mobile, AL 36608, (205) 344-7448. Olensky offers free shipping. (Most of the other dealers on this list charge extra for shipping.) Olensky's other prices are: $89 (instead of $150) for a 16K RAM chip set (you must pop the chips into the board yourself; it's easy and requires no soldering); $529 (instead of $595) for a disk drive with a controller; $475 (instead of $495) for a disk drive without a controller.

$994 at Your Own Computer Ltd., 10678 Campus Way South, Largo, MD 20870, (301) 350-6680.

$995 at Ucatan Computer Store, P.O. Box 1000, Destin, FL 32541, (904) 837-2022 and (904) 243-8565. $530 for a disk drive with a controller.

$1000 at The Computer Shop, 16919 Hawthorne Blvd., Lawndale, CA 90260, (213) 317-4010.

If you buy from a dealer who's not in your state, he won't charge you any sales tax.

If you ask a dealer to compare Apple against Radio Shack and Commodore, he'll tell you Apple is the best, Commodore is second-best, and Radio Shack is junk. (Instead of calling Radio Shack's computer the "TRS-80", he'll probably call it the "Trash-80".) The real reason he likes Apple is that Apple gives dealers the largest discount. Commodore gives a smaller discount, and Radio Shack gives hardly any discount at all. That's the real reason why he doesn't sell Radio Shack computers. (Radio Shack computers are *not* junk.)

One of the largest Apple dealers is NCE/Compumart, a mail-order house: 270 Third St., Cambridge, MA 02142, (617) 491-2700, out-of-state (800) 343-5504 toll-free. Compumart usually charges the full list price, but offers this discount: if you buy a 48K Apple 2-plus (i.e., an Apple with 48K of user RAM), you get $200 worth of accessories at no extra charge.

Apple charges $240 for a 9" black-and-white television monitor. That price is ridiculously high. As an alternative, Compumart will sell you a 9" black-and-white monitor manufactured by Sanyo, for a total price of $179. ($169 for the Sanyo, plus $10 for the cable that connects it to the Apple.) For $100 extra, Compumart will sell you a Sanyo that has a larger screen: 15 inches instead of 9.

If you want a color monitor, instead of black-and-white, Compumart will sell you Zenith's new 13" color monitor for $499.

If you'd rather use a normal television set (instead of a monitor), you must buy an RF modulator. Compumart recommends the "Sup R Mod 2" RF modulator, which costs $30.

Price comparisons

Suppose you want to buy a computer that has a decent version of BASIC, 16K of user RAM, and a tape recorder. Here's how Apple compares with Radio Shack....

Apple: $1195 + video + tape rceorder
Radio Shack: $849 (*including* the video and tape recorder)

Suppose you want to buy a computer that has 32K of user RAM and one 5-inch floppy-disk drive. Here's how Apple compares with Radio Shack....

Apple: $1940 + video
Radio Shack: $1796

Suppose you want to buy a computer that has 48K of user RAM, two 5-inch floppy-disk drives, and a Centronics printer. Here's how Apple compares with Radio Shack....

Apple: $2810 + video + printer
Radio Shack: $2444 + printer

Those are the *list* prices; remember that some Apple dealers and Radio Shack dealers offer discounts, and that you can pay less by plugging in RAM and disk drives manufactured by other companies.

COMMODORE

Commodore ranks third in popularity— right after Radio Shack and Apple. Commodore's computers are called the PET and the CBM. ("PET" stands for "Personal Electronic Transactor". "CBM" stands for "Commodore Business Machine".)

History

A while ago, the two most popular microprocessors in the world were the "8080" (manufactured by Intel) and the "6800" (manufactured by Motorola).

Some of the guys who invented the 6800 left Motorola and formed a new company, called "MOS Technology". This new company manufactured a microprocessor called the "6501", which was similar to the 6800 but better.

Motorola threatened to sue MOS Technology for patent infringement. To protect itself, MOS Technology stopped marketing the 6501 and instead began marketing the 6502, which was different enough from the 6800 to avoid lawsuit.

The 6502 became popular. One of the companies that used it was Commodore, whose headquarters were in Canada then. Commodore sold electronic pocket calculators that contained the 6502.

Motorola finally sued MOS Technology for the 6501. In the courts, the case dragged on for several years, and cost MOS Technology many thousands of dollars in legal fees. Finally, Motorola won, to the tune of $200,000.

That put MOS Technology into financial trouble, so it announced that it wanted to be bought by some rich company that had lots of cash. Commodore (a rich company) bought it.

Shortly before that sale, Canada's tax laws changed— to Commodore's disadvantage. So Commodore moved its headquarters (in theory) to the Bahamas. Commodore's profits are taxed by the Bahamas, where the tax rate is very low.

So MOS Technology became part of "Commodore Limited", a Bahamas company.

Since Commodore owned MOS Technology, Commodore could get MOS Technology's 6502 chips even more cheaply. Since profits in electronic pocket calculators were dropping (because of fierce market competition), Commodore switched its attention from calculators to computers. Its first computer, the PET, would include MOS Technology's 6502 CPU.

Commodore bragged that the PET would be an excellent computer and cost very little. At first, Commodore said the PET's price would be $495. That price would include *everything*: the CPU, the RAM, the ROM, the keyboard, the video, and the tape recorder. The ROM would have a good version of BASIC. The screen would display upper-case letters, lower-case letters, punctuation, mathematical symbols, and many wierder symbols also (such as hearts, diamonds, clubs, spades, curves, circles, and rectangles).

That frightened the other manufacturers of personal computers. Commodore's price was far lower than everybody else's. Commodore's computer offered far more features. And Commodore's wealth insured that Commodore could spend far more on advertising, marketing, and promotion than all the other manufacturers combined.

Many personal-computing magazines praised the PET and heralded it as "the birth of a new generation" in personal computers. Chuck Peddle, the guy who designed the PET, was treated to many interviews.

Commodore raised its price from $495 to $595, and began taking orders. To order the PET, the customer had to send the $595 in full, plus shipping charges, and then wait for Commodore to deliver.

Many people mailed Commodore the money and waited...and waited...and waited. Commodore didn't ship. People got impatient.

Computer stores got annoyed. The stores had advertised that they'd be selling Commodore's PET, and had received many orders from customers, but Commodore wasn't yet delivering to the stores. Customers complained to the stores, and the stores couldn't do anything to solve the problem.

While all that was going on, Radio Shack entered the market with its TRS-80 Model 1 Level 1 (priced originally at $599) and promised that Level 2 would come soon. At $599, Radio Shack's computer was about the same price as Commodore's PET ($595) and had several advantages:

To order, you had to give Radio Shack just a 10% deposit. (Commodore required pre-payment in *full*.)

Radio Shack didn't charge for shipping. (Commodore did.)

You could order Radio Shack's computer at any of the 6000 stores that Radio Shack had then. (Commodore had no such network.)

Radio Shack set up repair centers throughout the country. (Commodore's only repair center was in California.)

Radio Shack's monitor had a larger screen, and its keyboard had larger keys. (Commdore's PET strains your eyes and cramps your fingers.)

Radio Shack was even wealthier than Commodore and could therefore sink even more money into advertising and engineering.

Radio Shack delivered computers to customers quickly. (Commodore still wasn't delivering!)

Finally, Commodore made an announcement about delivery: Commmodore announced that the $595 PET would *not* be delivered in the near future! Instead, Commodore would deliver a $795 version, which would include 4K of extra RAM. So if you'd already sent $595 to Commodore and wanted a computer soon, you'd have to send an extra $200.

That was a rip-off. 4K of extra RAM is *not* worth an extra $200; it's worth much less. But customers were so desperate that they sent the $200 anyway.

Radio Shack shipped its computers on a first-come first-served basis. Commodore didn't: Commodore gave preferential treatment to its "friends". If you ordered a computer from Radio Shack, you could predict when it would arrive: Radio Shack would give you an accurate estimate. If you ordered a computer from Commodore, you hadn't the faintest idea of when it would arrive, because you didn't know how many "friends" were on Commodore's list.

When you ordered a computer from Radio Shack, you received a 232-page well-written easy-to-read cheery manual, written by David Lien and attractively bound. When you ordered a computer from Commodore, you received just 10 loose pages, which were tough to understand and were incomplete.

Commodore announced a low-cost printer; then Commodore changed its mind, and decided to sell only a more expensive printer instead. Commodore announced a low-cost disk drive; then Commodore changed its mind, and decided to sell only a more expensive unit instead, which contains *two* disk drives. (Even today, you can't buy just one disk drive from Commodore.) Those misleading announcements made the public's confidence in Commodore dip even further.

That's how Commodore entered the personal computing market. And that's why the PET (which people thought would be the best-selling computer) has managed to drop in popularity, below Radio Shack, and below even Apple.

As Commodore's fortunes dipped, Chuck Peddle and his friends quit, and were hired by Apple. But at Apple, they were treated as second-class citizens, so they returned to Commodore.

Perhaps all that history is irrelevant. Today, Commodore is an honest company that makes excellent computers.

Sales pitch

Commodore's PET costs about the same as Radio Shack's TRS-80, but is better in several ways. It's especially popular among high-school teachers. Here's why....

The PET is easy to carry from classroom to classroom, because its main cabinet contains everything— even the video and the tape recorder. (The TRS-80 is more awkward to carry, because it consists of four separate pieces— the main cabinet, the video, the tape recorder, and the AC/DC transformer, which are connected by ugly wires that tend to get tangled and confused. The Apple is awkward also.)

The PET is theft-proof. (The average thief wouldn't know how to use or resell a stolen PET. If you buy a TRS-80 instead, which has a separate tape recorder, the tape recorder will probably get stolen quickly. If you buy an Apple with a color TV, you can expect to lose the TV.)

When you make an error, the PET (like the Apple) prints a complaint that's written in easy-to-understand English. (The TRS-80 prints a two-letter code instead, which confuses the students.)

The PET includes a high-quality full-screen editor, which lets you revise your programs quickly and easily. (Its editor is much better than the TRS-80's, and even beats the Apple's.)

The PET's unusual keyboard has five kinds of symbols: upper-case letters, lower-case letters, punctuation, mathematical symbols, and graphics characters. (The Apple and the TRS-80 lack lower-case letters, and also lack graphics characters.) Therefore, the PET is superior for writing messages (which require lower-case letters) and for games (which require graphics characters).

The PET's tape recorder is reliable (unlike Radio Shack's). Moreover, you can name each program on the tape, and retrieve the program by mentioning the name. (Apple's computer doesn't let you name your taped programs. Radio Shack's computer permits "names", but each name must be just one letter!)

To encourage schools to buy the PET, Commodore had a "sale": if a school would buy two PETs, Commodore would give the school a third PET *for free*. Many schools took advantage of that "three for the price of two" sale. Notice that at three-for-the-price-of-two, the price per PET becomes $530, instead of $795. A PET for $530 was definitely a better deal than what Radio Shack and Apple were offering. Officially, that sale has ended; but if you're lucky, maybe you can twist the arm of your local computer dealer, to give you a discount anyway.

Main cabinet

The main cabinet includes a keyboard. You can buy three kinds of keyboards. The model C keyboard has tiny keys, like a pocket *calculator*. The model N keyboard has larger keys, like a *normal typewriter*. The model B keyboard is similar to the model N keyboard, but is organized in a fashion that pleases *businessmen*; it's less convenient for playing games.

So if you're a businessman, get the model B; if you're using the computer for fun, get the model N. The model C is the worst keyboard, since its keys are so tiny. But the model C has one offsetting advantage: if you get the model C keyboard, you also get a *free* tape recorder!

The main cabinet includes the keyboard (and a built-in tape recorder, if you chose the model C), a 9" black-and-white monitor, a 6502 CPU, a 14K ROM (containing BASIC and the operating system), "system" RAM (to help the input and output), and a "user" RAM (for your programs). The price depends on which keyboard you choose, and how much user RAM you want:

	Model C keyboard and tape recorder	Model N keyboard (without tape recorder)	Model B keyboard (without tape recorder)
8K user RAM	$795	$795	not available
16K user RAM	not available	$995	$995
32K user RAM	$1195	$1295	$1295

Commodore has stopped manufacturing the model C keyboard; but some dealers still have the model C in stock, and that's what you'll still find in most schools.

If your user RAM is just 8K, your computer is called a PET; if your user RAM is 16K or 32K, it's called a CBM.

If you get the model N or model B, you get a new operating system (called the "CBM operating system"), which can handle disk drives and and a printer. If you get the model C, you get the old operating system (called the "PET operating system"), which is more limited, and which makes some errors.

Peripherals

To use peripherals (such as disk drives, printers, and extra tape recorders), you must buy cables. The first cable costs $50; each additional cable costs $40. You need one cable per peripheral. So if you have just one peripheral, your total cost for cables is $50; if you have two peripherals, your total cost for cables is $50 + $40 = $90; if you have three peripherals, your total cost for cables is $50 + $40 + $40 = $130.

The tape recorder costs $95. The disk-drive unit (including a controller, *two* disk drives, and an 11K ROM containing the DOS) costs $1295. The printer costs $849 if you want friction-feed, $995 if you want tractor-feed.

Those prices are high— but so is the quality. The tape recorder is ultra-reliable. The disk-drive unit, manufactured by Shugart, is unusual: it squeezes 180K onto each 5" floppy disk; so altogether, the unit handles 360K; and since the DOS is included on the 11K ROM, you do *not* have to copy the DOS from a disk to a RAM, which would waste time and also hog lost of space in your RAM. (The TRS-80 and the Apple suffer from that problem.) The printer (manufactured by Epson) uses regular paper, and can print upper case letters, lower-case letters, punctuation, mathematical symbols, and *even the graphics characters!* (It prints 80 characters per line at 70 lines per minute, bidirectionally, via a 7-by-6 dot matrix.) The printer includes its own controller and a 4K ROM, which makes the printer automatically edit your output.

So Commodore's peripherals are fancier than Radio Shack's and Apple's.

Dealers

Some dealers give discounts:

Multi-Business Computer Systems
28 Marlborough St.
Portland, CT 06480
(203) 342-2747
8K model N for $680 (instead of $795)
16K model N or B for $884 (instead of $995)
32K model N or B for $1075 (instead of $1295)
tape recorder for $89 (instead of $95)
disk-drive unit for $1090 (instead of $1295)
friction-feed printer for $799 (instead of $849)
tractor-feed printer for $899 (instead of $994)
If you pay $15 extra for the model N or B, you'll get $75 worth of programs (about personal finance, baseball, and kaleidoscopes).

AB Computers
115 E. Stump Rd.
Montgomeryville, PA 18936
(215) 699-8386
You get $100 worth of merchandise, free, if you buy an 8K PET (model N).
You get $110 worth of merchandise, free, if you buy a friction-feed printer.
You get $130 worth of merchandise, free, if you buy a 16K CBM or a tractor-feed printer.
You get $170 worth of merchandise, free, if you buy a 32K CBM or a disk-drive unit.

ARGUMENTS

The most popular microcomputer company is Radio Shack. Apple ranks second. Commodore ranks third in popularity. But "popular" doesn't mean "best". Which of those three companies is the best?

Argument for Radio Shack (Model 1)

It has the lowest list price; and many dealers offer discounts below even that! It's the only one that lets you start at a very low price ($499) and gradually add onto it, as you get richer. It's the only one that understands fancy logic: it understands words such as ELSE and PRINT USING and DEFDBL. It's the only one that gives previous customers free copies of new improvements. (Apple and Commodore charge extra for new improvements.) More programs have been written for it than for any other microcomputer. More compatible hardware is available for it than for any other microcomputer. The screen holds 64 characters per line. (For the Apple and Commodore, the screen holds only 40 characters per line.)

Argument against Radio Shack (Model 1)

Its editor is the clumsiest. Its salesmen know the least about computers. It's the least portable— since it comes in so many little pieces, strung together by ugly wires. Its screen shows only 16 lines of text. (Apple's screen shows 24; Commodore's shows 25.)

Argument for Apple

It has the best-written manuals. It's the only one that draws pictures in color. It's the only one that has high-resolution graphics: it lets you plot teensy-weensy points on the screen.

Argument against Apple

It's the most expensive— especially when you add in the price of the video and the tape recorder. (Moreover, if you use an ordinary television set instead of a monitor, the characters on the screen will be fuzzy.)

Argument for Commodore

It's the most portable. It has the fanciest peripherals. It's the only one whose keyboard includes graphics characters. It's the only one that can display lower-case letters on the screen. It's the only one that lets you give long names to programs on the tape.

Argument against Commodore

It has the worst manuals. It has the fewest repair centers (though Commodore is trying to correct that.) Commodore overcharges for RAM. (Commodore charges $200 for 8K, and $300 for 16K; Apple charges $150 for 16K; Radio Shack charges $149 for 16K.) It's the only one that can't be expanded easily. (If you buy a small 8K PET, you can't easily expand it to a 32K CBM.) It's the only one that forces you to use a small screen (9 inches). Since it's the least popular of the big three, fewer business and scientific programs have been written for it (though you can find plenty of games). Because Commodore's cable and peripherals are so unusual, fewer compatibles are available from independent sources, and so you'll find fewer discounts and bargains: you're at the mercy of Commodore.

Alternative microcomputers

CHART

Though Radio Shack, Apple, and Commodore are the most "popular", they aren't necessarily the "best". Look at their competitors— which in some ways are better.

This chart compares 16 microcomputers; all of them work well; each one has its own peculiar advantages:

Manufacturer	Model	Base price	User RAM included	Higher price	Price includes keyboard?	Price includes video?	Price includes tape recorder?	Price includes disk drive?	Draws pictures in color?	Graphics characters on keyboard?	Accepts ROM cartridges?	Lower-case letters on screen?	Convenient touch-typist keyboard?	Invent your own characters?	Uses co-ordinates for graphing?	Easy high-resolution graphing?	Lines of text on screen	Characters per line	Type of CPU
Ohio Scient.	Challenger 1P	$349	4K	unpublished	Y	N	N	N	N	N	N	Y	Y	N	N	N	30	30	6502
Atari	400	$550	8K	unpublished	Y	N	N	N	Y	N	Y	Y	N	N	Y	Y	24	40	6502
Radio Shack	Model 1 Level 2	$619	4K	$849 if 16K	Y	Y	Y	N	N	N	N	N	Y	N	Y	N	16	64	Z-80
Ohio Scient.	Challenger 4P	$698	8K	unpublished	Y	N	N	N	Y	N	N	Y	Y	N	N	N	32	64	6502
Commodore	C	$795	8K	$1195 if 32K	Y	Y	Y	N	N	Y	N	Y	N	N	N	N	25	40	6502
Commodore	N or B	$795	8K	$995 if 16K	Y	Y	N	N	N	Y	N	Y	Y	N	N	N	25	40	6502
Atari	800	$1000	8K	$1125 if 16K	Y	N	Y	N	Y	N	Y	Y	Y	N	Y	Y	24	40	6502
Texas Instr.	99/4	$1150	16K	none	Y	Y	N	N	Y	N	Y	N	N	Y	Y	N	24	32	9900
Apple	2-plus	$1195	16K	$1345 if 32K	Y	N	N	N	Y	N	N	N	Y	N	Y	Y	24	40	6502
Exidy	Sorcerer	$1295	16K	$1395 if 32K	Y	N	N	N	N	Y	Y	Y	Y	Y	N	N	30	64	Z-80
Compucolor	2	$1595	8K	$1895 if 16K	Y	Y	N	Y	Y	N	N	N	Y	N	Y	N	32	64	8080
North Star	Horizon	$2695	32K	$3434 if 64K	N	N	N	Y	N	N	N	Y	Y	N	N	N	24	80	Z-80
Heath	WH89 + H89-17	$2795	16K	$2945 if 32K	Y	Y	N	Y	N	N	N	Y	Y	N	N	N	25	80	Z-80
Intertec	Superb.+BASIC	$3345	32K	$3695 if 64K	Y	Y	N	Y	N	N	N	Y	Y	N	N	N	25	80	Z-80
Radio Shack	2	$3450	32K	$3899 if 64K	Y	Y	N	Y	N	N	N	Y	Y	N	N	N	24	80	Z-80
Vector Gr.	MZ	$4313	64K	none	N	N	N	Y	N	N	N	Y	Y	N	N	N	24	80	Z-80

The "base price" is the list price of the smallest combination that includes a decent version of BASIC. Some dealers charge less than the base price. You'll have to pay *more* than the base price if you want more RAM, or if you want a fancier version of BASIC, or if you want other extras. For some computers, the base price does *not* include a keyboard or video or tape recorder or disk drive; for other computers, the base price includes most of those items; look at the columns marked "Price includes...".

If the base price includes a keyboard but doesn't include video, you must buy an ordinary television set (with an RF modulator) or a modified television set or a television monitor. If the base price includes *neither* a keyboard nor video, you must buy a terminal.

If the base price includes neither a tape recorder nor a disk drive, you must buy one or the other: if you're poor, buy a tape recorder; if you're rich, buy a disk drive (and controller). Exception: the Atari 400 won't yet accept a disk drive; so you *must* buy a tape recorder.

The chart arranges the computers in order of base price: from the cheapest to the most expensive. But remember that the "base price" is misleading, unless you also look at the columns marked "Price includes...".

If you're rich, and want to buy a fancy computer, you have two choices:

1. buy a computer that has a high base price
2. buy a computer that has a low base price, and then add extras (such as disk drives)

Either way, you win— because *all* the computers in that chart are good.

In the chart, I drew a horizontal line underneath Apple. The computers above that line are "cheap"; the computers below that line are "expensive".

For the cheap computers, the base price is *under* $1200. For the expensive computers, the base price is *over* $1200.

For the cheap computers, the base price does *not* include a disk drive, which costs extra. For expensive computers, the base price *does* include a disk drive. (The only exception is the Exidy Sorcerer.)

For the cheap computers, the base price includes 4K, 8K, or 16K of user RAM. For the expensive computers, the base price includes 16K, 32K, or 64K. (The only exception is the Compucolor 2.)

For the cheap computers, each line contains 30, 32, 40, or 64 characters. For the expensive computers, each line contains 64 or 80 characters.

If you multiply "characters per line" by "lines of text on screen", you get "characters on screen". For the cheap computers, the number of characters on the screen is about 1000. For the expensive computers, the number of characters on the screen is about 2000. (The only exception is the Ohio Scientific Challenger 4P.)

For the cheap computers, the CPU is a 6502. For the expensive computers, the CPU is a Z-80. (The only exceptions are the Radio Shack Model 1, the Texas Instruments 99/4, and the Compucolor 2.)

All the cheap computers have this in common: the keyboard is built into the main cabinet, and is included in the base price.

All the expensive computers have this common: the base price does *not* include a tape recorder (because you're supposed to use disks instead); the computer does *not* offer easy high-resolution graphing (because you're supposed to want "serious business features" instead of graphing); and the computer's keyboard *is* convenient for touch-typists (though it might not be included in the base price).

The 16 computers in that chart come in pairs. Let's look at each of the 8 pairs....

RADIO SHACK

Radio Shack's pair consists of the "Model 1 with Level 2 BASIC" and the "Model 2". (Radio Shack also makes a "Model 1 with Level 1 BASIC", but it's junk.)

The Model 1 with Level 2 BASIC is the most popular microcomputer, because its low price includes the main cabinet *and* the video *and* the tape recorder; and its version of BASIC includes fancier logic than any of the other cheap computers. Radio Shack's thousands of stores enable you to buy the computer quickly and easily and get it repaired quickly too.

The Model 2 is in the "expensive" category and is somewhat overpriced. Its base price is misleading: to turn it into a decent business system, you must add more RAM, and you ought to add another disk drive. Radio Shack charges you $1100 for the second disk drive. Instead of buying a Model 2, you might do better to add Corvus's 10-megabyte hard-disk drive to the Model 1: that combination has much more memory than the Model 2, yet costs about the same.

In spite of those comments, I expect the Model 2 will sell well; and it *is* a reasonable computer to buy. But it's not the "miracle bargain" that the Model 1 is.

Since the Model 2 is new, few programs have been written for it yet; probably you'll have to write your own. By contrast, *thousands* of canned programs have already been written for the Model 1.

COMMODORE

Commodore's pair consists of the Model C and the Model N&B. The Model C is the better deal, since its base price *includes* the tape recorder. But Model C's keys are tiny; if your fingers can't fit on them, you must get the Model N (or B) instead.

If you're planning to buy disks, you won't need the tape recorder anyway, so you won't want the Model C; get the Model N (or B), to please your fingers.

If you want the Model C, remember that Commodore has stopped manufacturing it, but it's still available from many sources.

APPLE & TEXAS INSTRUMENTS

The Apple 2-plus and the Texas Instruments 99/4 resemble each other. Both can draw pictures in color. Both cost between $1100 and $1200.

Originally, Apple charged more. But when Texas Instruments invented the 99/4 and announced that it would cost just $1150, Apple quickly lowered its own price, to compete.

Texas Instruments' base price *includes* a color monitor; Apple's base price does not; so Texas Instruments seems the better deal. But if your home already has a color television set, the Texas Instruments color monitor seems a needless luxury.

Because the Texas Instruments 99/4 is new, few programs have been written for it yet, and few peripherals have been attached to it yet. So to leave your options open, buy an Apple. On the other hand, if you like fancy stuff, you'll prefer the Texas Instruments, which has many weird and wonderful things programmed into its 26K ROM (which is much larger than Apple's).

To analyze how Apple compares against Texas Instruments, stare at the chart. If possible, visit a computer store and peek at both computers.

Although the Texas Instruments list price is $1150, some dealers charge less: Raygam charges $920; Your Own Computer charges $994; Multi-Business Computer Systems charges $995; Factory Direct Sales charges $1000.

OHIO SCIENTIFIC

Ohio Scientific's computer is called the Challenger; it comes in many models. The chart shows the two models that are obviously "bargains"; if you get a chance, visit an Ohio Scientific dealer and peek at the other models too. On the largest model, you can even attach a hard-disk drive that contains 74 megabytes!

Of all the computers on the chart, the Challenger 1P is the cheapest: its list price is just $349. (One dealer, Olensky, sells it for just $329, and doesn't even charge you for shipping!) When you add an RF modulator and attach it to your home's television set and tape recorder, you have a nice system. The Challenger 4P is more expensive than the 1P, but has three advantages: it can handle color; it can handle more RAM; and it shows more characters on the screen.

Ohio Scientific will annoy you: its manuals are poorly written and too brief; the keys on its keyboard are poorly labeled (for example, the @ symbol is omitted); and the error messages are erroneous (they are printed in graphics characters instead of in English). In short, Ohio Scientific computers are "incomplete and unpolished". But at those low prices, how can you say no? With the money you've saved, you can buy disks, printers, and other goodies, which more than make up for the little hassles.

ATARI

Atari's computer is new. I predict it will be an outstanding success.

It comes in two models: the Model 400 and the Model 800. Both models have the same intelligence. The Model 800 costs more, for three reasons: it has a better keyboard, it has more space for holding extra RAM, and its base price *includes* the tape recorder. If you want disks, you must choose the Model 800.

The Model 800 resembles the Apple 2-plus but is better. Its superiority lies in three areas: drawing fancy pictures (in color), playing music, and printing English characters onto the screen. Though the Apple can do all those things, Atari does them better. Moreover, the Atari is cheaper!

But before you rush out to buy an Atari, keep these factors in mind:

Though Atari's base price is lower than Apple's, Atari's price for additional RAM is higher.

The Apple is definitely excellent. Though the Atari seems even better, it's new and hasn't yet stood "the test of time".

Many programs and peripherals are available for the Apple. **Few** are available for the Atari yet.

You can buy the Atari at Sears, at J.C. Penny's, and at computer stores. J.C. Penny's gives you a $200 discount, if you buy the disk drive (and controller) at the same time as you buy the Model 800. Raygam has an even better deal: 20% discount on all major Atari items.

EXIDY & COMPUCOLOR

Recently, Exidy and Compucolor raised their prices. (The chart shows their new, high prices.)

The Exidy Sorcerer resembles the Commodore Model N, but has extra keys on the keyboard and costs more. The Compucolor 2 resembles the Texas Instruments 99/4, but includes a disk drive and costs more.

Though the Exidy Sorcerer lets you invent your own characters, it's awkward at drawing fancy pictures that cover the entire screen. Though the Compucolor 2 can draw fancy pictures in color, the commands that do the drawing involve code numbers, which you must memorize; so the Compucolor 2 is more difficult to use than the Apple or Atari or Texas Instruments.

In spite of those negative comments, you might like Exidy and Compucolor, because their keyboards are so beautifully elaborate. "One look, and you'll fall in love!"

Exidy's keyboard contains 79 keys. Compucolor's normally contains 71 keys; but for an extra $225, you can get 117 keys; Compucolor's keys are in pretty colors.

Radio Shack's Model 1 contains only 53 keys, and the Apple 2-plus contains only 52. Exidy and Compucolor are lots more fun!

INTERTEC & HEATH

Intertec makes a display terminal, called the Intertube 2. Recently, Intertec has invented a new version of that terminal: the new version (called the Superbrain) has enough goodies hidden inside to make it a complete computer system. The "goodies" include a 32K user RAM, an extra Z-80 CPU, and two disk drives (which are built into the cabinet, and on the right side of the screen; they're where you'd expect to find a television dial). The disk drives (manufactured by BASF) hold 5-inch double-density disks; the total capacity of the two disks, combined, is 320K formatted.

Heath's history is similar. Heath makes a display terminal, called the WH19. Recently, Heath has invented a new version of it; the new version (called the WH89) has a 16K RAM, an extra Z-80 CPU, and a disk drive (on the right side of the screen). The disk drive (manufactured by Wangco and Siemens) holds 102K. To use the disk drive, you must buy H89-17, which is a disk containing the DOS and BASIC.

Intertec and Heath both have impressive keyboards. Intertec's has 80 keys; Heath's has 84.

The Intertec Superbrain is better than the Heath WH89, in several ways: the Superbrain has two disk drives (instead of one); the Superbrain's disk drives are double-density (instead of single-density); and the Superbrain can handle "Microsoft BASIC version 5.01" (which is fancier than the versions of BASIC offered by Heath).

But because the Superbrain is fancier than the WH89, it is more expensive. The Superbrain costs $2995; its BASIC costs an extra $350. The WH89 costs $2695; its H89-17 (DOS and BASIC) costs an extra $100.

Get the Superbrain, if you can afford it. If you can't, get the WH89 instead. If you can't afford even the WH89, get the Heathkit H89 instead: it's exactly the same as the WH89, but comes as a do-it-yourself kit, instead of assembled; it costs $1000 less than the assembled version. So if you're willing to put the computer together yourself (by following Heath's easy-to-read instructions), you can save $1000! You pay $1695 instead of $2695.

At $1695, the Heath is a bargain. Many do-it-yourselfers are buying it and saving lots of money. Why not you?

Those are Heath's new prices. (Heath used to charge even less, but raised its prices recently. As you can see, the new prices are still good deals.)

As for the Superbrain, in many ways it's a better deal than Radio Shack's TRS-80 Model 2. For example, the Superbrain costs less; its version of BASIC is better; and its base price includes *two* disk drives instead of just one. (On the other hand, Radio Shack's DOS is easier to understand, and Radio Shack's 8-inch disks hold more than the Superbrain's 5-inch disks, and go faster.)

If you're a businessman, remember that you want *two* disk drives: if you have just one disk drive, you can't make a copy of a disk easily. The Superbrain includes two drives; the WH89 and the TRS-80 Model 2 include just one (though you can buy extras).

One dealer, Multi-Business Computer Systems, is selling the 64K Superbrain for $5 *less* than the 32K Superbrain's list price; so you save $355.

NORTH STAR & VECTOR GRAPHIC

This is the last of the 8 pairs.

Recently, North Star and Vector Graphic rasied their prices. The chart shows their new, high prices.

This is the only pair of computers in which the base price does *not* include the keyboard: you must buy a terminal. When you add the base price to the terminal's price, the result is a very high price. So if you have little money, do *not* buy from North Star or Vector Graphic.

North Star's base price includes 32K in RAM, plus 179K on disk (a double-density 5-inch floppy). Vector Graphic's base price is higher, because it includes 64K in RAM, plus 630K on disks (two "quadruple"-density 5-inch floppies).

North Star sells fancier versions than base-price one. If you want to buy a version that looks like Vector Graphic's— with 64K in RAM, plus 630K on disk— North Star charges $4334. That's just slightly more than Vector Graphic's price ($4313). As you can see, North Star and Vector Graphic are "neck and neck". If one of them ever changes its price again, the other company will probably do the same.

Like Heath, North Star gives you the option of buying a kit. But North Star's kit saves you only $696; Heath's kit saves you $1000; so if you want to buy a kit, Heath is the better bargain. And anyway, on April 1, 1980, North Star will stop manufacturing the kits.

American Square Computers is a dealer that offers discounts on North Star computers. Usually, the discounts are 20% (sometimes slightly more, sometimes slightly less). For example, American Square Computers charges $2156 for the base price (instead of $2695), and charges $1585 for the same item in kit form (instead of $1999). During the first few months of 1980, American Square Computers is charging even *less* than that.

RECOMMENDATIONS

For "serious" applications, I recommend the Radio Shack Model 1 with Level-2 BASIC, because it costs so little, and because so many programs and peripherals have already been invented for it. For "fun" applications, I recommend the Atari 800, because it has beautiful color graphics and four-part harmony.

Those are my personal favorites. But yours might be different. Choosing a computer is a matter of personal taste. Shop around. Taste the various flavors. You don't have to settle for vanilla. Get whatever turns you on— and is reasonable. The 16 computers in the chart are all decent; the only question is which computer best meets *your* needs.

If you want to chat, give me a buzz. At your service, your computer butler,

Russ Walter

1981 update

Pages 1 through 64 were written at the beginning of 1980. Since then, the computer industry has continued to grow. Here's what happened at the end of 1980 and in 1981....

RADIO SHACK has invented a third major computer, called the "model 3". It's a compromise between the model 1 and the model 2. Radio Shack is also selling two "minor" computers, which cost even less than the model 1: the minor computers are called the "Color Computer" and the "Pocket Computer". Because of all these new computers, Radio Shack has stopped selling the model 1.

APPLE has raised its prices for the Apple 2 and Apple 2-plus. Apple has also invented a higher-priced computer, called the Apple 3. Most industry experts feel the Apple 3 is over-priced, and recommend that you get just the Apple 2-plus. The Apple 2-plus has become extremely popular: it's outselling Radio Shack, and is the best-selling microcomputer.

COMMODORE has invented a wonderful new low-cost computer, called the VIC. You can get it for under $300. Because the VIC is such a good bargain, Commodore has stopped selling the stripped-down versions of the PET and CBM. But Commodore is continuing to offer the higher-priced *souped-up* versions of the PET and CBM, for programmers who insist on fanciness. Commodore has improved its marketing staff and moved its U.S. headquarters to Pennsylvania.

INTERTEC (which makes the Intertube terminal and Superbrain computer) has gotten a bad reputation, because of its poor quality control and poor policy about repairs. But if you buy an Intertec product through a reputable dealer, the dealer will take care of the hassles for you.

TELEVIDEO, a new company, has become the most popular manufacturer of display terminals. Televideo's terminals are outselling the ones by Intertec, Hazeltine, and Lear Siegler.

THE PRICE OF RECEIVE-ONLY PRINTERS has dropped dramatically. The most popular printer is the Epson MX-80, which you can buy for under $500. The lowest-cost printer that can print 80 characters per line on normal paper is the Bytewriter, which you can buy for under $300.

HARD DISKS— which used to come in just two sizes, 14" and 8"— are now available in a smaller size (5"), for people who want to spend less money.

RAYGAM— the discount dealer that offered super-low prices— went bankrupt, so lots of customers lost their money.

A NEW CROP OF RADIO SHACK AND APPLE DISCOUNT DEALERS has arisen. The new crop offers better discounts than the old crop.

FOR MORE DETAILS ABOUT 1981, get volume 4, by using the coupon on the next page.

Coupon

SHARE

Share your secret: photocopy this page, and give it to a friend. If you know a young (or young-at-heart) computerist who's having a birthday, Christmas party, or graduation, turn these volumes into a present: send me the computerist's name, address, and either a greeting card or what you want me to say.

VOLUMES

This tenth edition of *The Secret Guide to Computers* consists of eight volumes:

Volume	Topic
1: Popular BASIC	the easiest way to program, using many dialects of BASIC
2: Hassles in BASIC	advanced BASIC, data files, graphics, programming style
3: Popular Systems	kinds of computer equipment, how they work, buzzwords
4: Hassles in Systems	the newest computers, operating systems, your career
5: Popular Applications	what computers have done and can do
6: Hassles in Applications	advanced programming techniques for advanced applications
7: Popular Languages	FORTRAN, COBOL, PASCAL, comparison with BASIC
8: Hassles in Languages	assembly languages, dozens of high-level languages

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___ how you can get *The Secret Guide to Tricky Living* (volume 1 is called "Sex"; volume 2 is called "Everything But")

On the other side, write your name, address, and any comments you have (pro or con) about *The Secret Guide to Computers*. Make check or money order payable to Russell M. Walter. Send to Russ Walter, 92 Saint Botolph St., Boston, MA 02116.

"IN"TRODUCTION

(This "in"troduction is only for people who are "in". If you're "out of it"— if you're the kind of person who insists on wearing a necktie even in bed— read the "out"roduction instead.)

Congratulations! You've decided to learn about computers! That's reasonable— especially when you consider that computers all over the country are trying to learn about *you*.

This book will turn you into a computer expert, even if you're an idiot. In fact, *some of the most famous computer experts in the world have read this book*— and are idiots!

Computers, like people, come in all sizes: you can get big ones, little ones, and pip-squeaks. The big'uns are called *maxicomputers* (or *mainframes*); little'uns are called *minicomputers*; and the teeny-weeny itty-bitty pip-squeaks are called *microcomputers*.

But how big is big? How little is little? How teeny-weeny is teeny-weeny? Opinions differ. It's like trying to measure a person. What's a "big" person? It could mean three things:

You're tall.
You're fat.
You're sexually well-endowed.

The same is true for computers.

Yes, the word "maxicomputer", like the word "big", is vague. But here are some guidelines....

Usually, a maxicomputer fills a room; a minicomputer fits in a corner; a microcomputer freaks-out on a desktop. Usually, a maxicomputer costs anywhere from $4,000,000 down to $150,000; a minicomputer costs from $150,000 down to $10,000; a microcomputer costs from $10,000 down to $300.

Women have different tastes, when they choose men. Some women like men who are tall. Other women prefer men who are more on-the-level.

The same goes for computers. Some people like computers that are huge. Other people prefer computers that are cuddly.

The most popular maxicomputer has been the IBM 370 (which is being replaced by the IBM 3030 and the IBM 4300); the most popular minicomputer is the PDP-11; the most popular microcomputer is the TRS-80. Big IBM operates out of plush offices. Digital Equipment Corporation (fondly called DEC), which makes the PDP-11, operates out of an abandoned wool mill. Radio Shack, which makes the TRS-80, operates out of el-cheapo discount stores. If you can't afford a computer, Radio Shack will try to sell you, as a booby prize, a CB radio instead.

About computers, people get emotional. Insulting someone's computer is like insulting your mother. People who own big IBM's say, "All those little computers are shit." People who own DEC's say, "We got a good deal." People who own Radio Shack's say, "You stupid rich bastards! Our computers are as good as yours and'll take on *all* you big boobs, any day! C'mon and fight!"

But before you buy a computer, look at the competition. IBM, DEC, and Radio Shack aren't the only fish in the sea; some of their competitors are better. Treat a computer company just as you'd treat a person of the opposite sex: walk up and say, "Show me yours!"

I'm married to a computer. Marrying a computer is much groovier than marrying a person. For one thing, computers are good at "getting it on": they make you feel all electric and tingly. And computers never argue: they're always ready to "do it" (except when they "have a headache"). I wanted to call this book "The *Sexual* Guide to Computers", and put a picture of me and my wife on the cover; but some parts of the country still prohibit mixed marriages. That cover would be banned in Boston, where (alas!) is where I live. So I had to play it cool, and say "Secret" Guide to Computers. But here's the real secret: this book is about sex.

"OUT"RODUCTION

(for people who are "out of it")

This book is a sober analysis of the different computers, and how to program them. Don't worry— I promise never to mention sex again. At least not directly.